Manuscript Report No. 91-02

Abundance and Reproductive Success of Colonial Waterbirds on Lake Winnipegosis, 1987 - 1989.

By McMahon, Blair and Koonz, William.

Manitoba
Natural Resources
Wildlife
Biological Services

91-03929/

ABUNDANCE AND REPRODUCTIVE SUCCESS OF COLONIAL WATERBIRDS ON LAKE WINNIPEGOSIS, 1987 - 1989

Blair McMahon
William Koonz
BioServices
Department of Natural Resources
1495 St. James Street
Winnipeg, Manitoba

ABSTRACT

The status and productivity of colonial waterbirds was investigated on approximately 40 islands and reefs on Lake Winnipegosis from 1987 through 1989. Double-crested Cormorants (Phalacrocorax auritus) and American White Pelicans (Pelecanus erythrorhynchos) were the most intensively monitored species and provided regurgitate samples for an assessment of food habits. The number of cormorants nesting on Lake Winnipegosis increased dramatically from about 1,500 in 1969 to 8,700 in 1979. There were 35,191 cormorant nests counted in 1987, 30,857 in 1988 and 51,759 in 1989. The number of pelican nests on Lake Winnipegosis changed from approximately 3,700 in 1979 to 2,400 in 1984 and 1985 to 3,700 in 1987 and 1988 to 6,000 in 1989. Seven other colonial waterbird species nested together with cormorants during the study period. Ring-billed Gulls were the most numerous of the other waterbird species, but Herring Gulls were widely distributed over the lake. Lake Winnipegosis contains the largest concentration of breeding Caspian Terns in Canada.

Evidence of human disturbance was found at 15 cormorant colonies in 1987 and at 11 colonies in 1989. Although human disturbance had an observable impact on other waterbird species, cormorants were the ones most seriously affected. Human disturbance resulted in the destruction of approximately 10,000 and 43,000 cormorant young that would have fledged in 1987 and 1989, respectively. Nearly 11,000 food samples were collected from cormorants in 1987 and 1988. Yellow Perch (Perca flavescens) were the most common prey species, but White Sucker (Catostomus commersoni) made up nearly half the prey biomass. The commercially valuable species, Walleye (Stizostedion vitreum) and Sauger (S. canadense) accounted for 0.2% and 0.3% of the prey biomass. Of the 209 prey samples collected from white pelican regurgitates, Yellow Perch and 9-spined Sticklebacks (Pungitus pungitus) were the most common species. Walleye and sauger each comprised 0.5% of the pelican food sample.

ACKNOWLEDGEMENTS

The study's field coordinators were Richard Knapton in 1987 and Keith Hobson in 1988. Harvey Brown was the owner and operator of the boat used throughout the study. Darcy Carlson was cook and field assistant on most boat trips. Gordon Thompson took his boat to colonies in August, 1990. Local field and logistical assistance was also provided by Wayne Brown, Milton Brown, Ray Flemming, James Flemming, Robert Contois and Arthur Gabrielle. John Koonz, Barbara Hanbidge and James Thompson collected field data. Gerry Edwards (Fisheries Branch) provided logistical support for this study while the Provincial Fisheries Branch provided funding for most of the boat rentals. World Wildlife Fund Canada was a major financial contributor. Financial support was also provided by the Canadian Wildlife Service and the Provincial Wildlife Branch. Dr. Merlin Shoesmith (Chief of BioServices) supported the project, provided staff time, gave direction and edited the manuscript.

TABLE OF CONTENTS

	Page
ABSTRACT	i
ACKNOWLEDGMENTS	ii
LIST OF TABLES	iv
LIST OF FIGURES	v
INTRODUCTION	1
METHODS AND MATERIALS	2
Study area	2
Procedure	2
RESULTS	3
Colony description	3
Population trends	18
Human disturbance of colonial waterbirds	18
Cormorant diet	19
Pelican diet	19
DISCUSSION	24
Population trends	24
Human disturbance	24
Diet	24
SUMMARY	25
LITERATURE CITED	26
APPENDICES	28

LIST OF TABLES

Table		Page
1.	Number of nests of Double-crested Cormorants and American White Pelicans on Lake Winnipegosis colonies in 1987, 1988 and 1989 .	5
2.	Number of nests of some colonial waterbirds on Lake Winnipegosis colonies in 1987 and 1989	6
3.	Influence of human disturbance on Double-crested Cormorant productivity (No. fledging/nest) on Lake Winnipegosis	20
4.	Influence of human disturbance on American White Pelican productivity (No. fledging/nest) on Lake Winnipegosis in 1989	21
5.	Composition of prey species found in regurgitation samples of Double-crested Cormorants from Lake Winnipegosis in 1987 and 1988	22
6.	Composition of prey species found in regurgitation samples of American White Pelicans from Lake Winnipegosis in 1989 . . .	23

LIST OF FIGURES

Figure — Page

1. A map of Lake Winnipegosis showing the location of colonial waterbird colonies 4

INTRODUCTION

American White Pelicans (Pelecanus erythrorhynchos) and Double-crested Cormorants (Phalacrocorax auritus) arrive at their breeding grounds in late April and throughout May (Markham 1978a,b). Pelicans are a ground nesting species found on islands and reefs in five Canadian provinces (Markham 1978a, Koonz 1987). Although most cormorants are ground-nesters which breed in the same colonies as pelicans and other colonial waterbirds, small populations of cormorants frequently nest in trees on islands and mainland areas adjacent to lakes (Vermeer 1973). In Manitoba, pelicans and cormorants are frequently found in colonies containing a combination of as many as nine waterbird species (Koonz and Rakowski 1985).

The total number of pelicans that annually breed in Canada increased from 15,560 pairs in 1977 to 54,678 in 1986 (Markham 1978a, Koonz 1987). Since the early 1970's, dramatic increases have also occurred in the number of Double-crested Cormorants in North America (Hatch 1983, Buckley and Buckley 1984, Roney and Hlady 1984, Vermeer and Rankin 1984, Craven and Lev 1987, Findholt 1988, Hobson et al. 1989). The rapid increases in pelican and cormorant populations may be attributed to a reduction in the persecution of these birds by humans, lowered levels of organochlorine contaminants, increased availability of nesting habitat, increases in food abundance through the production of man made water impoundments and the proliferation of fast growing forage fish (Vermeer 1969, Koonz and Rakowski 1985, Weseloh et al. 1983, Price and Weseloh 1986, Vermeer and Rankin 1984, Findholt 1988).

Recent increases in numbers of cormorants have been a growing cause of concern among commercial fishermen from various regions in North America (Bayer 1989). Commercial fishermen from Lake Winnipegosis, in Manitoba, have blamed cormorants for Walleye (Stizostedion vitreum) declines. People have responded by destroying many of the cormorants that nest on the islands and reefs of this shallow lake. Lake Winnipegosis contains the largest breeding population of cormorants in Manitoba and has a unique diversity of nesting colonial waterbird species.

The present study examines population estimates of colonial waterbird species nesting on Lake Winnipegosis from 1987 to 1989. The diet of cormorants was examined in 1987 and 1988 and the diet of pelicans was examined in 1989. The location of each species in a colony was mapped out. Man's impact on the reproductive success of pelicans and cormorants was also evaluated.

MATERIALS AND METHODS

Study area

Lake Winnipegosis is a large, shallow body of water located in the west-central portion of Manitoba (Fig. 1). It is approximately 200 km long, has a maximum width of about 35 km and a surface area of 497,017 ha. Mean water depth is 4.24 m. Numerous islands and rocky reefs provide colony sites for American White Pelicans, Double-crested Cormorants, Herring Gulls (Larus argentatus), California Gulls (L. californicus), Ring-billed Gulls (L. delawarensis), Common Terns (Sterna hirundo), Caspian Terns (S. caspia), Forster Terns (S. forsteri), Great Blue Herons (Ardea herodias), and Black-crowned Night-Herons (Nycticorax nycticorax). Reefs typically have substrates of boulders, sand, gravel and compact guano and are usually less than 2 m above water level. Several islands are vegetated. Trees and shrubs on these islands include Manitoba Maple (Acer negundo), Green Ash (Fraxinus pennsylvanica), American Elm (Ulmus americana), Red Osier Dogwood (Cornus alba) and current (Ribes spp.). Forbs include nettles (Urtica spp.), coltsfoot (Petasites spp.), Giant Ragweed (Ambrosia trifida), and Lamb's Quarter (Chenopodian album).

Procedure

The islands and reefs of Lake Winnipegosis that contained breeding populations of cormorants and pelicans were surveyed during six boat surveys between 15 May and 6 September in 1987. Surveys of colonies were performed on 15-20 June and 11-15 July in 1988 and 1-8 July and 13-17 August in 1989. Nest counts were made of all colonial waterbird species on these colonies. Clutch sizes for cormorants was determined in 1988 at colonies well into incubation. In 1989, the number of nests predated, destroyed or abandoned was noted. The spatial relationships between avian species was noted on topographical maps drawn for each colony. Forbs, shrubs, trees and rocks were drawn on each map.

Food regurgitated by cormorants at their breeding colonies was collected in 1987 and 1988. Prey were sampled uniformly within randomly chosen subsections of colonies. In addition, any Walleye or Sauger (S. canadense) encountered were collected; the maximum proportion of these prey are represented in the diet. All prey were identified to species, weighed, and the fork length measured. On 6 July 1989, samples of fish regurgitated by pelicans were collected on a pre-selected portion of Dory's Reef.

In 1988, cormorants were banded primarily on Hay Island Reef and Coffey's Point Reef 1-3 and 13 July. Juvenile cormorants were banded at Red Deer Point Reef on 4 July 1989.

RESULTS

Colony Description

Lake Winnipegosis breeding colonies are shown in Figure 1. Topographical maps of colonies are provided in Appendix 1 and give a detailed description of the islands and reefs occupied by the colonial waterbirds of Lake Winnipegosis in 1989.

1. Bachelor's Island: In 1987, 392 cormorant nests were present (Table 1). Ring-billed Gulls, Herring Gulls and California Gulls also nested on this island in 1987 (Table 2).

In 1988, 1352 cormorant nests were present. Of these, 21 were in trees. Most nests contained chicks approximately 14 days old when visited on 20 June. On 11 July, 3344 mobile young were present, indicating an approximate nestling survival rate of 2.5 chicks/nest.

Ring-billed Gulls and Herring Gulls nested alongside a large colony of cormorants in 1989 (Table 1). This island contained a large, healthy colony when visited on 15 June. On 2 July, all cormorant and gull nests were empty; no carcasses or egg fragments were found and a single cormorant chick, 10 to 14 days old, was present on the island. The island was littered with shotgun shell casings. A commercial fisherman from the area later reported that people from Winnipegosis threw all the eggs and young into the water.

2. Sugar Island Reef: On 8 June 1987, 2454 cormorant nests and 694 pelican nests were counted (Table 1); both species had young at various ages and some pairs still had eggs. By 18 June, pelican chicks were at various stages of creching (leaving their nests and joining loose aggregations of mobile juveniles) and on 3 August there were about 75 fledged chicks, giving a productivity of 0.11 chicks per pair. There were four Great Blue Heron nests among the tree-nesting cormorants (Table 2). Also, five immature Black-crowned Night-Herons were present in mid-July, indicating breeding by that species.

In 1988, this colony was first visited on 9 May. Approximately 1000 nests had been initiated but clutches of 2-3 eggs were counted. Five nests on the north side of the island were built on snow. Three kills of adults, apparently by Bald Eagles (Haliaeetus leucocephalus), were found. On 31 May, 70-80 pelicans and 500 cormorants roosted here. Only 2 cormorant eggs were found. Cormorant nests had been worked on but had since been abandoned. On 14 June, a small colony of 58 cormorants and 5 pelicans was found. Cormorant nests were at the 0-3 egg stage. Approximately 100 Ring-billed Gulls (Larus delawarensis) roosted on the island. By 1 July, this colony was deserted. Thus, no colonial waterbirds successfully nested here in 1988.

Nearly 2000 cormorants and 500 pelicans nested on this reef in 1989 (Table 1). All of these birds nested in the shade of maple, ash and elm trees that covered approximately 75% of the reef.

3. Hay Island Reef: Sixty-three pelican nests were counted on 8 June, 1987

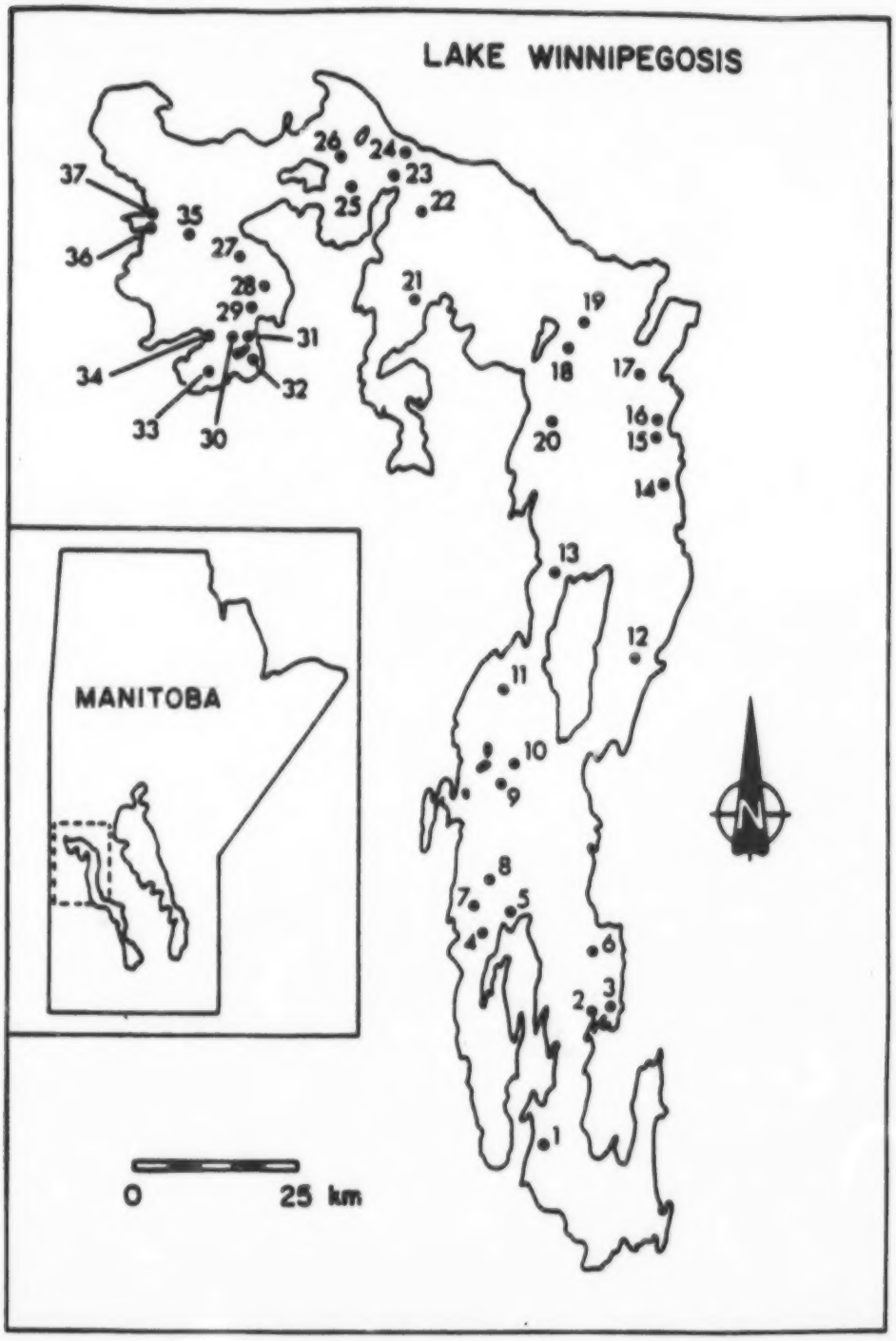


Figure 1. A map of Lake Winnipegosis showing the location of colonial waterbird colonies.

Table 1. Number of nests of Double-crested Cormorants and American White Pelicans on Lake Winnipegosis colonies in 1987, 1988 and 1989.

Colony	Cormorant			Pelican		
	1987	1988	1989	1987	1988	1989
1. Bachelor's Island	392	1352	1286			
2. Sugar Island Reef	2454	0	1881	694	0	500
3. Hay Island Reef	1823	2622	2640	63	83	713
4. Coleman Island	74	198	50			
5. Red Deer Point	543	646	1131			
6. Coffey's Reef	727	1649	1326			
7. Gambler's Point	523	0	388			
8. Smokey Island	575	366	487			
9. S. Camping Island	1445	1190	3139	15	34	32
10. N. Camping Island	79	0	76			
11. Sealey's Island	335	492	38	1	2	0
12. Baby Sister's Island	269	678	958	0	0	5
13. Gobbler Island	726	492	312			
14. Dead Baby's Reef	628	1040	1928	0	0	3
15. S. Goose Island	66	129	117			
16. N. Goose Island	844	1001	1007			
17. Denbeigh Point	491	489	430			
18. S. Cormorant Island	2540	1683	2424	25	0	1
19. N. Cormorant Island	1856	1080	1497	0	0	2
20. Spruce Bluff	135	0	20			
21. Whiskey Jack Reef	200	160	122			
22. S. Little Channel Island	986	796	1248			
23. Long Island (S)	3303	2999	8349	345	662	1666
24. Long Island (N)	3509	3077	7157	489	421	1037
25. Channel Island (NW)	2048	1144	1743	1201	471	0
26. Dory's Reef	2168	1400	2050	886	1150	1980
27. Vance's Reef	359	620	790			
28. Mason Reef	295	265	238			
29. Mason Island	366	142	470			
30. Balabas Island (S)	100	75	185			
31. Bluff Island	2259	2196	3990			
32. Angus Reef	99	66	148			
33. Archie's Island	107	48	0			
34. The Gobbler	1222	903	1552			
35. Rowan Island	927	391	599			
36. Birch Point Reef	501	529	1144			
37. Whitefish Point Reef	217	337	363			
38. Net Point	0	358	0			
39. South Sagemace Bay	-	141	150			
40. Rock Island	-	103	0			
Total	35191	30857	51778	3719	3750	5939

Table 2. Number of nests of some colonial waterbirds on Lake Winnipegosis colonies in 1987 and 1989.

Colony	Ring-billed Gull		Herring Gull		California Gull		Caspian Tern		Common Tern		Great Blue Heron		Black-crowned Night Heron	
	'87	'89	'87	'89	'87	'89	'87	'89	'87	'89	'87	'89	'87	'89
1. Bachelor's Island	*[1]	77	50	1	5	0								
2. Sugar Island											4	0		
3. Hay Island Reef			31	0							6	0	*	0
4. Coleman Island			17	2										
5. Red Deer Point			4	0										
6. Coffey's Reef	0	8	0	2					0	47	0	11	0	10
7. Gambler's Point			0	1										
8. Smokey Island			0	1										
9. S. Camping Island			11	1					*	0	47	16		
10. N. Camping Island	*	0	47	21					*	0				
11. Sealey's Island	*	715	19	1	288	*	*	1084	*	0	12	5		
12. Baby Sister's Is.			5	0							39	1	0	4
13. Gobbler Island			15	0							1	0		
14. Dead Baby's Reef	0	300	15	7					0	47	19	11		
15. S. Goose Island			8	0										
16. N. Goose Island	*	71	10	7			*	299						
17. Denbeigh Point			15	3			*	10	*	0				
18. S. Cormorant Is.	0	14	40	0										
19. N. Cormorant Is.	0	7	12	1					0	17				
20. Spruce Bluff			8	0										
21. Whiskey Jack Reef			20	0										
22. S. Little Chan. Is.			20	5	24	0								
23. Long Island (S)	*	644	10	2	415	*					0	5		
24. Long Island (N)	*	37	40	2	84	0					15	29	*	0
25. Channel Island (NW)	*	2500	1	0			*	920	*	*				
26. Dory's Reef	0	67	35	0	6	0	*	450	*	100				
27. Vance's Reef			31	50										

Table 2 (cont'd)

Colony	Ring-billed Gull		Herring Gull		California Gull		Caspian Tern		Common Tern		Great Blue Heron		Black-crowned Night Heron	
	'87	'89	'87	'89	'87	'89	'87	'89	'87	'89	'87	'89	'87	'89
28. Mason Reef														
29. Mason Island			10	0									0	2
30. Balabas Island (S)			0	2										
31. Bluff Island			47	9										
32. Angus Reef														
33. Archie's Island														
34. The Gobbler														
35. Rowan Island														
36. Birch Point Reef			0	1										
37. Whitefish Point Reef			11	8										
38. Net Point														
39. South Sagemace Bay														
40. Rock Island														
Total	*	4448	532	119	822	*	*	2763	*	*	143	62	*	16

[1] The species was present, but the total number of nests was not counted

(Table 1); 22 of the nests had young and 41 contained eggs. Chicks were creching by 18 June, about 25 fledged and 10 unfledged young were present on 3 August, giving a productivity of 0.56 chicks per pair. On 8 June, there were also 1823 cormorant nests containing eggs to nearly grown young. Six Great Blue Heron nests were counted among the tree nesting cormorants (Table 2). There were 31 Herring Gull nests counted in early June.

On 9 May 1988, this colony contained 1973 cormorant nests (0egg=1194; 1e=613; 2e=131; 3e=5). Thirty nests were in trees. Four Herring Gull, 3 California Gull and 1 pelican nest was also present. By 31 May, 2622 cormorant nests were present; 29 of these in trees. Five pelican nests had also been initiated. On 14 June, 83 pelican nests were found. Cormorant nests at that time were primarily at the 0-5 day chick stage. By 13 July, 4194 mobile young were present, indicating a nestling survival rate of 1.6 chicks/nest. Only 27 pelican nests remained, 9 containing recently hatched young.

When visited on 15 June 1989, there were 2640 cormorant nests on the ground and 16 in the trees. Cormorant, pelican and Herring Gull chicks were 7 to 14 days old and were at least one week older than young from surrounding colonies. Many juvenile pelicans were mobile and near the creching stage.

4. Coleman Island: Fewer than 100 cormorant nests were present on this island in 1987 (Table 1). There was also a small population of Herring Gulls (Table 2).

Nearly 200 cormorant nests were present on 19 June 1988. Nests contained eggs and renesting had clearly been initiated after human disturbance occurred. Numerous shotgun shell casings were found.

Only 1 of the 50 cormorant nests and 2 of the 37 Herring Gull nests were active on 4 July 1989. The eggs from both species had been picked and most nests were abandoned.

5. Red Deer Point: This reef is circular in shape and has a narrow, rocky peninsula extending from one end (see Appendix). In 1987, 543 cormorant and 4 Herring Gull nests were present. On 19 June 1988, 646 cormorant nests were counted in two subcolonies. One contained chicks approximately 14 days old and the other contained chicks 0-1 day old. In 1989, Approximately 83% of the 1131 cormorant nests present on 4 July were located near the center of the reef. Young from this section of the island were much older than those raised on the peninsula.

6. Coffey's Reef & Island: In 1987, 727 cormorant nests were counted on the reef. The presence of cormorants on the island was not detected.

On 14 June 1988, 781 cormorant nests were counted on the reef. Seventeen of these were in low, dead trees. The treed island north of the reef was found to contain cormorants in 1988 and there was evidence of use in previous years. On 14 June, 868 cormorant nests were found on the island. Fifty-six of these nests were in trees. By 13 July, 2509 young were present on the island, indicating a nestling survival rate of 2.9 chicks/nest.

Nestling survival on the reef was 1.6 chicks/nest.

Many ground-nesting cormorants were present on the reef in 1989. Only 2 Herring Gull nests were present on this reef. On Coffey's Island, willows (Salix spp.) were found along the periphery of dense stands of Manitoba Maple and American Elm. All cormorants nested in the area covered by trees. Most cormorants were ground-nesters; only 8% of the 826 nests were located in trees. Black-crowned Night-Herons nested within a dense stand of willows bisecting the two cormorant subcolonies (see Appendix). Numerous Common Terns, a few Ring-billed Gulls and one Canada Goose (Branta canadensis) were present on the northeast end of the island.

7. Gambler's Point: This colony was used by nesting cormorants in 1987, but not 1988 (Table 1). Despite being largely covered by water, nearly 400 cormorants nested on this reef in 1989. Both the density of nesters and their reproductive success were exceedingly high when compared to other colonies.

8. Smokey Island: In 1987, 575 cormorant nests were found on the island; 366 cormorant nests were present on 19 June 1988. Most nests contained chicks 0-1 day old. Of the 487 cormorant nests observed on 4 July 1988, over 99% contained one or more chicks. Cormorants from this colony had very high reproductive success, similar to the neighbouring colony. The population of cormorants increased by 33% in 1989 (Table 1). A single Herring Gull nest was also present.

9. South Camping Island: This island was more than a kilometer long, having a rocky shoreline on the southern half and a mud shoreline on the northern half. Low bushy trees grew in the northern half, while dead mature trees dominated the southern half. In 1987, several hundred cormorant nests and many Great Blue Heron nests were in the trees (Table 1). All of the 15 pelican nests counted on 3 June contained eggs. None of the eggs had hatched by 16 June, and only 3 by 7 July. No young were found on 5 August. On 3 June, 1445 cormorant nests were counted; many were in trees and about 150 contained young. The largest Great Blue Heron colony encountered during this year was on this island, with 47 nests counted on 3 June. Eleven Herring Gull and about 150 Common Tern nests were also present.

On 18 June 1988, 1190 cormorant, 34 pelican and 9 Great Blue Heron nests were present; 192 of the cormorant nests were in trees. Most cormorant nests contained chicks 10-18 days old. By 12 July, 2800 mobile young cormorants and 28 mobile young pelicans were present, indicating a pre-fledging success rate of 2.4 and 0.8 chicks/nest for these two species, respectively.

In 1989, most cormorants nested on the elevated ridge that covered the southern half of the island (see Appendix); approximately 10% of the cormorants nested on the ground within the treed region of the island. While there was a 2.6 fold increase in cormorant numbers from the previous year, pelican numbers remained stable (Table 1). All pelicans nested under the trees. Their young varied widely in age, from hatchlings to creching young approximately 4 weeks old. Herring Gulls and Great Blue Herons were also present in 1989 (Table 2).

10. North Camping Island: This island was used by cormorants in 1987 but, due to high water levels, no nesting occurred in 1988. In 1989, the cormorants on this small colony were approximately 10 days old when counted on 4 July.

11. Sealy's Island Reef: This reef consisted of two rock and mud islands with a few small bushes in the middle, and a rock and mud islet with low vegetation of forbs to the north of the main island. The cormorant colony at the south end of the reef held 262 nests on 3 June 1987, all with eggs. No young were present on 16 June or 7 July, and none were found on 5 August. One pelican nest was in this colony on 3 June, but the eggs had disappeared by 16 June. A colony on the northern reef held 73 cormorant nests on 3 June. Young were well developed on 16 June, but only about 50 fledged young were observed on 5 August. Twelve Great Blue Heron nests, 288 California Gull nests and 19 Herring Gull nests were counted on 3 June. By 16 June, there were about 3000 pairs of Ring-billed Gulls, 150 pairs of Caspian Terns and 50 pairs of Common Terns present.

In 1988, 492 cormorant nests were present on 18 June; 4 of these were tree nests. Two pelican nests were counted. Large colonies of Caspian Terns and Ring-billed Gulls were present but were not censused. Five Great Blue Heron nests were present and several of these had Common Grackle (Quiscalus quiscula) nests in association. By 12 July, 380 mobile cormorant chicks were present, indicating a pre-fledging survival rate of 0.8 chicks/nest.

In 1989, Sealy's reef contained numerous cormorants, Caspian Terns and Ring-billed Gulls in addition to Great Blue Herons and a few Blue-winged Teal (Anas discors)(Tables 1, 2). Caspian Terns and Ring-billed Gulls were the only species nesting in close association with each other on one section of the colony (see Appendix). Most (83%) of the 1084 tern nests were located on the southern half of the reef. In this area, young terns ranged from 2 to 21 days in age. In the northern subcolony, most nests contained two eggs and the few chicks were less than 7 days old. The majority of Caspian Terns nested within the vegetated regions and the remainder nested on the beach ridge, normally within one meter of the vegetation. Nests along the beach ridge were shallow depressions in the sand, the remainder contained some nesting material taken from the surrounding Artemesia spp. plants. On 13 August, 17 Caspian Tern nests containing eggs and/or hatchlings were present in the northern subcolony. A juvenile gull, possibly attacked by a raptor, was found decapitated and partly dismembered.

12. Baby Sister's Island: In 1987, this island contained 269 cormorant nests. There was a small population of Herring Gulls and a large number of Great Blue Heron nests (Table 2). On 15 June 1988, 678 cormorant nests were present on this island. Most nests had young 0-5 days old. At least 15 Great Blue Heron nests were present.

In 1989, pelicans, cormorants, Great Blue Herons and Black-crowned Night-Herons all nested on this island (Tables 1, 2). Only 3% of the cormorant population nested in trees. Of the ground nesters, 60% were located in areas devoid of vegetation and 37% nested within or along the periphery of treed regions (see Appendix). All pelicans nested under the trees. Five minutes prior to our arrival on 8 July, two people were seen moving through

the colony. Mortality among cormorants included 70 chicks that had been clubbed to death; numerous young were wounded and 50 to 100 chicks were thermally stressed from being herded and/or thrown into the lake. This colony was not censused in August.

13. Gobbler Island: In 1987, 726 cormorants were present. There were also Herring Gulls and a Great Blue Heron nesting on this island (Table 2).

On 18 June 1988, 492 cormorant nests were present. Most nests were at the egg stage, indicating that the colony had previously been disturbed. Several nests contained eggs that had been baked with a flame thrower. This island contained a navigational marker that was serviced in May. By 12 July, 150 mobile cormorant chicks were present. At least 200 nests contained newly hatched chicks (0-5 days). Renesting had occurred after birds abandoned "baked" clutches.

All 312 cormorant nests observed on 5 July 1989, contained 3 to 5 eggs, none having yet reached the piping stage. Embryos were approximately 7 to 14 days old, indicating that renesting was recent. Recently fired shotgun shell casings were scattered throughout the nesting area. A survey on 13 August revealed that renesting was asynchronous: 429 cormorant chicks were almost identical in age, 10 to 14 days old, while 161 nests contained day old hatchlings and pipping eggs. Fledging success for all renests was estimated at 1.9 chicks/nest.

14. Dead Baby's Reef: This reef contained 628 cormorant nests in 1987. Herring Gulls and Great Blue Herons also nested on this reef (Table 2).

On 15 June 1988, 1040 cormorant nests were counted of which seventeen were in trees. Four pairs of Great Blue Herons and several hundred pairs of Ring-billed Gulls nested there.

At least 8 avain species, including grackles and Red-winged Blackbirds (Agelaius phoeniceus), nested on this reef in 1989 (Tables 1, 2). All pelicans and 33% of the cormorants nested underneath trees or around shrubs. Only 7 of 1929 cormorant nests were located in trees. Gulls nested in open regions between cormorant subcolonies (see Appendix). Nearly all gull chicks were mobile on 8 July and had fully fledged by 13 August.

15. South Goose Island: In 1987, 66 cormorant and 8 Herring Gull nests were present. On 15 June 1988, 129 cormorant and 4 Herring Gull nests were present. Most cormorant nests contained newly hatched young, 0-1 day old, or eggs. This small, boulder-covered reef contained only 117 cormorant nests in 1989.

16. North Goose Island: In 1987, 844 cormorant nests were present. Ring-billed Gulls, Herring Gulls and Caspian Terns also nested here in 1987.

On 15 June 1988, 1001 cormorant nests containing eggs and chicks (1-5 days old) were present as were 245 Ring-billed Gull, 7 Herring Gull, and 5 Caspian Tern nests.

Numerous cormorants and Caspian Terns nested alongside Herring and Ring-billed Gulls in 1989 (Tables 1, 2). Approximately 50 to 100 Common Tern nests were also located on an adjacent reef. All cormorant nests were located on an elevated ridge. On 8 July, most nests contained young; along the periphery of the cormorant colony were found regions were nests contained only eggs. Most Caspian Tern nests contained young ranging in age from hatchlings to approximately 14 days old. On 14 August 1989, 5 pre-fledged Caspian Terns were found decapitated. Additionally, 20 to 30 similarly aged terns had recently died but showed no external reason for mortality.

17. Denbeigh Point: The population of cormorants remained stable between years. There were 491 cormorant nests on this reef in 1987. Herring Gulls, Common Terns and Caspian Terns also nested here (Table 2).

On 15 June 1988, 489 cormorants nested here. Approximately 150 Ring-billed Gull, 5 Herring Gull, and 2 Caspian Tern nests were found.

While cormorants nested in two subcolonies in 1989, on open elevated ridges, a small population of Caspian Terns nested among the forbs (see Appendix). The location of Ring-billed Gull and Caspian Tern nests within densely vegetated regions of the reef precluded accurate estimates for these species.

18. South Cormorant Island: On 15 June 1988, 1603 cormorant nests were counted. On 13 July, 1800 mobile cormorant chicks were present. This indicates a pre-fledging nesting success of 1.1 chicks/nest.

In 1989, a large population of cormorants nested on the slightly elevated ridge extending the length of the island (Table 1). On 8 July, most nests contained young 7 to 14 days old. Three subcolonies contained hatchlings and/or eggs and were located away from the ridge, near the water. A single pelican nest was located near the center of the main colony.

19. North Cormorant Island: In 1987, 1856 cormorant nests and 12 Herring Gull nests were present.

On 15 June 1988, 1080 cormorant nests with chicks just hatching (0-1 day) were counted. Ten Herring Gull nests were also found. On 13 July, approximately 2000 mobile cormorant chicks were present, indicating a pre-fledging nesting success o 1.9 chicks/nest. A total of 132 chicks had been shot.

Cormorants, pelicans, Common Terns, Forster's Terns, Herring and Ring-billed Gulls all nested on this island in 1989 (Tables 1, 2). Numerous adult Forster's Terns were observed, but their nests were not counted. Of the Common Tern nests, 12 contained chicks and 5 contained eggs. This colony had been disturbed by humans prior to our visit on 8 July. Two to four hundred cormorant chicks were recently killed and many nests were destroyed. Most cormorants nested on an elevated ridge. Two small subcolonies present in flat regions close to the water had nests containing only eggs. Gulls and terns nested among weeds on the opposite end of the island.

20. Spruce Bluff: This colony contained 135 cormorant nests and 8 Herring Gull nests in 1987. It was not censused in 1988. In 1989, the few cormorant nests present on this reef were all abandoned. There was no evidence of human disturbance and cormorants appear to have deserted prior to egg laying.

21. Whiskey Jack Reef: Two hundred cormorant nests and 20 Herring Gull nests were present on this reef in 1987.

On 13 July 1988, 160 empty nests and 280 mobile cormorant chicks were present. This indicates a pre-fledging success rate of approximately 1.8 chicks/nest.

In 1989, all of the 122 cormorant nests had been abandoned. No eggs or young were present in any nest. A resident indicated that local people had picked eggs from this colony previously.

22. South Little-Channel Island: There were 986 cormorant nests in addition to 20 Herring Gull and 24 California Gull nests in 1987.

On 18 June 1988, 796 cormorant nests were present. Nests contained chicks 0-12 days old. On 13 July, 850 mobile cormorant young were counted. This indicates a pre-fledging success rate of 1.1 chicks/nest.

In 1989, a large population of cormorants nested along a 2 m high ridge extending the length of the island. Only 5 Herring Gull nests were present.

23. Long Island South: This reef was separated by about 200 m from a large northern reef. The southern reef was comprised of rock, gravel, mud and guano at the north end merging into trees, shrubs and forbs (nettles, coltsfoot) towards the south, ending in marsh. This was a heavily vegetated colony dominated by maple, elm and dogwood (see Appendix). On 21 May 1987, there were 345 pelican nests and 3303 cormorant nests on this reef. The largest colony of California Gulls was located here; on 21 May, there were 415 nests. There were also about 1000 Ring-billed Gull nests and 10 Herring Gull nests. On 8 July, there were about 500 creching cormorant chicks, giving a pre-fledging success of 0.6 chicks/nest.

On 18 June 1988, there were 2999 cormorant nests on this reef; 69 of these were in trees. A total of 662 pelican nests were also counted. On 13 July, 404 creching pelicans and 8500 young cormorants were present. This indicates a pre-fledging success rate of 0.6 and 2.8 for pelicans and cormorants, respectively.

In 1989, this was the largest colony on Lake Winnipegosis (Table 1). Most pelicans and cormorants nested on the flattened ridge that rose 4-6 m above the water. Most pelicans (76%) nested adjacent to trees and shrubs and the remainder nested directly under trees and shrubs. Most cormorants (97%) nested on the ground. For ground nesting cormorants, 62% nested in areas devoid of vegetation and 38% nested under trees or shrubs. Ring-billed and Herring Gulls nested in the open at the northern and southern ends of this reef. Humans had visited this island the day before and destroyed 450 cormorant nests on the northern end of the island. Estimates for the number

of trampled Ring-billed Gull nests are lacking.

24. Long Island North: This reef, 800 m x 35 m, had rock and gravel shorelines with trees and shrubs in the center. On 21 May 1987, there were 489 pelican nests and 3509 cormorant nests present. There were 84 California Gull nests, 1500 Ring-billed Gull nests, 40 Herring Gull nests, 15 Great Blue Heron nests and at least 2 pairs of Black-crowned Night Herons. About 500 creching pelican chicks were present on 8 July, giving 0.6 chicks/nest.

On 18 June 1988, 421 pelican and 3077 cormorant nests were present. Twenty five of the cormorant nests were in trees. A large Ring-billed Gull colony was present but was not censused. On 13 July, 247 mobile pelican chicks and 5500 cormorant chicks were counted, indicating a pre-fledging nesting success rate of 0.5 and 1.8 for pelicans and cormorants, respectively.

In 1989, most cormorants (94%) were ground nesters located along a ridge running the length of the reef. Few pelicans (13%) nested in the open, 87% nested underneath or beside vegetation. On 5 July, all pelican nests located in areas devoid of vegetation contained either eggs or young less than 7 days old. Much older young were located among treed areas: 91% of all young were creching, while the remaining nests contained 2 day old hatchlings. Herons nested in the trees above the pelicans. Humans entered this island on 5 July and destroyed young cormorants and pelicans on the northern end of the colony. Approximately 883 cormorant nests containing 14 day old young were destroyed. Of the pelican nests that were destroyed, 9 contained eggs and 65 contained 1-7 day old chicks.

25. Channel Island N.W.: This was a 250 x 30 m rock, gravel and sand reef with extensive patches of nettles and coltsfoot in the center. Marsh vegetation and mud flats occurred on the island's north and northwest sides. There were 1201 pelican nests counted on 21 May 1987. Young were well developed by 29 June, but not as advanced as those on Dory's Reef. There were about 500 highly mobile chicks in creches on 10 July, 30 nests with eggs and 10 nests with newly-hatched young, giving 0.44 chicks per pair at this stage. As on Dory's Reef, there were about 100 dead young on 10 July. This colony expanded from the rock, gravel and sand part into the marsh and mud area on the north end of the island where Forster's Terns and Franklin's Gulls were also nesting. On 21 May, 2048 cormorant nests were counted. This colony flourished over the summer, with about 4000 well grown, highly mobile young on 10 July, for about 1.95 chicks per pair at this stage. Only one active Herring Gull nest was found; this suggests the possibility of egg collecting. About 100 Ring-billed Gull pairs and 150 Caspian Tern pairs were nesting on the island. Common Terns were also present. The colony of Forster's Terns, at about 100 pairs, was the largest encountered on the lake, and about 50 pairs of Franklin's Gulls was the most northerly breeding colony of this species found.

On 18 June 1988, 1144 cormorant nests containing 0-5 day old chicks were present. There were also 471 pelican nests containing 0-10 day old chicks and 20 Caspian Tern nests. On 13 July, 252 mobile pelican chicks and 1660 mobile cormorant chicks were present. This indicates a pre-fledging nesting success of 0.5 and 1.5 for pelicans and cormorants, respectively.

In 1989, this colony contained large populations of cormorants, Caspian Terns, thousands of Common Terns and Ring-billed Gulls (Tables 1, 2). Cormorant nests were situated along an elevated ridge. Caspian and Common Tern nests were primarily located in densely vegetated areas containing .5-1.0 m high goosefoot and sweet clover. Approximately 1/4 to 1/3 of the Caspian and Common Tern population nested in unvegetated flats adjacent to cormorants. The young from 2 Caspian Tern nests were dismembered. Approximately 2000 Franklin's Gulls were loafing on mudflats connected to the island.

26. Dory's Reef: This was a 575 m x 35 m reef of rocks, gravel and compacted guano, with vegetation (primarily pigweed) growing over 50% of the center of the colony. On 21 May 1987, 886 pelican nests were counted, and by 29 June most pelican eggs had hatched; there were several well developed and highly mobile creches of young. On 10 July, there were about 500 mobile young, 10 nests with newly hatched young, and 15 nests still with eggs for a productivity of about 0.58 chicks per pair. There were about 100 dead pelican chicks of various ages in the colony on 29 June. On 21 May, 2168 cormorant nests were counted. Six California Gull and 35 Herring Gull nests were also counted. By late June, there were about 300 pairs of Caspian Terns and 150 pairs of Common Terns. There were probably 250 Caspian Tern chicks on the gravel and in the vegetation.

On 18 June 1988, there were estimated to be 2300 pelican and 1400 cormorant nests present. On 12 July, 908 creching pelicans and 2500 mobile cormorants were present. The approximate pre-fledging nesting success rate was 0.4 and 1.8 for pelicans and cormorants, respectively.

In 1989, this colony contained a large population of cormorants, pelicans and Caspian Terns (Tables 1, 2). Pelicans and cormorants nested on the flattened ridge. Caspian Terns nested along the sand beach ridge and among the forbs. Numerous Ring-billed Gulls and 80 to 200 Caspian Tern nests were trampled by 6 week old pelican young.

27. Vance's Reef: There were 359 cormorant pairs nesting on this reef in 1987. Thirty-one Herring Gull nests were also present.

On 17 June 1988, this colony had 620 cormorant and 4 Herring Gull nests. A younger subcolony was apparent on the east end of the reef. These nests contained several pebbles as well as eggs. On 13 July, 271 mobile cormorant chicks and 105 nests with eggs or newly hatched chicks were present.

In 1989, this colony contained 790 cormorant and 50 Herring Gull nests. Cormorants nested in 2 subcolonies, the smaller one located adjacent to a Herring Gull colony.

28. Mason Reef: In 1987, 295 cormorant nests were present. On 17 June 1988, 265 cormorant nests were counted. These contained young 0-5 days old. In 1989, 238 cormorant nests and 14 Ring-billed Gull nests were present on this reef. Cormorant nests were located on a narrow ridge.

29. Mason Island: There were 366 cormorant nests and 10 Herring Gull nests on

this island in 1987. This tree colony contained 142 cormorant nests on 17 June 1988. Only a small region of this large, heavily vegetated island contained nesting birds in 1989. All cormorants nested in elm and maple trees. Five juvenile cormorants were found dead, apparently from natural causes. Numerous Common Grackle nests were located beside cormorant nests. Great Blue Heron, Black-crowned Night Heron and one Mallard (Anus platyrhynchos) nest were also located in the area occupied by cormorants (Table 2).

30. Balabas Island: In 1987, 100 cormorant nests were present.

On 17 June 1988, 75 cormorant nests were counted. All nests were in trees. Some evidence of human disturbance was found (e.g. climbing poles up trees). Two Herring Gull nests were also counted.

Although this island was densely vegetated, 14.6% of all cormorants nested on the ground in 1989. Common Grackles nested in close association with tree nesting cormorants. Although hundreds of adult Herring Gulls were seen flying around this colony on 7 July, only 2 nest were located.

31. Bluff Island: In 1987, 2259 cormorant nests were present. There were also 47 Herring Gull nests.

This is a large island rising 10 m to 20 m above the water. On 17 June 1988, 2196 cormorant nests were present. Of these, 471 were in trees. Most nests contained young 0-5 days old.

In 1989, many cormorants (17%) nested in the elm and maple trees located along the periphery of the colony. Most (73%) of the colony nested among the dogwood bushes that dominated the understorey. The remainder of cormorants (10%) nested on the rocky, southern ridge which rose at a 70 to 80 degree angle. On 7 July, numerous dead adult and juvenile cormorants were observed. Many of these birds had been shot; shotgun shell casings were scattered throughout the northwestern end of the colony, where the dead birds were located. Rough estimates revealed that 3% to 13% of all nests were destroyed. On 16 August, 5 juvenile cormorants were found with their pectoral muscles missing. The pattern of dismemberment indicates that a large raptor visited this island.

32. Angus Reef: This was a small, rocky reef containing 99 cormorant nests in 1987. In 1988, the colony was destroyed by locals from Dawson Bay. Evidence of 66 abandoned cormorant nests remained on 17 June. On 7 July 1989, most of the 148 young were between 7 and 25 days old. Only 5 of the 148 nests contained newly hatched young. This colony was not visited in August.

33. Archie's Island: There were 107 cormorant nests on this island in 1987.

High water resulted in a reduction of nest sites at this site in 1988. Only 48 cormorants nested there on 17 June. Nests contained eggs or newly hatched young.

In 1989, the few nests present on this island were abandoned. The eggs

had been collected by humans.

34. The Gobbler: In 1987, 1222 cormorant nests were present.

On 17 June 1988, 903 cormorant nests were present. Of these, 62 were tree nests. Most nests contained newly hatched young 0-1 day old.

A large population of cormorants and a few Ring-billed Gulls nested on this island in 1989 (Tables 1, 2). Only 3.7% of the cormorant population nested in the elm trees that were sparsely dispersed throughout the colony. Being approximately 4 weeks old on 7 July, juvenile cormorants were similar in age to those on surrounding colonies.

35. Rowan Island: There were 927 cormorant nests on this island in 1987. On 17 June 1988, 391 cormorant nests were present. This colony contained 599 cormorant nests in 1989.

36. Birch Point Reef: In 1987, 501 cormorant nests were present.

On 17 June 1988, 529 cormorant nests were counted. Most nests contained chicks 0-10 days old. By 13 July, 1800 mobile cormorant chicks were present. This indicates a pre-fledging success rate of 3.4 chicks/nest. Locals from Whitefish Point reported that several dead chicks from this colony had washed up after a strong east wind.

In 1989, cormorant nests were located in 2 subcolonies positioned on the northern and southern extremes of the reef. Prior to our visit on 6 July, people had entered the colony and destroyed 20 nests. Approximately 40 to 50 juvenile cormorants, 3 to 4 weeks in age, were destroyed.

37. Whitefish Point Reef: This is a small reef having low-lying areas dominated by stands of bulrush (Scirpus spp.). In 1987, 217 cormorant nests were present there.

On 17 June 1988, 337 nests were counted. By 13 July, 430 mobile cormorant chicks were present, indicating a pre-fledging success rate of 1.3 chicks/nest.

In 1989, cormorants nested along an elevated ridge, while a small population of Ring-billed Gulls nested within and beside a stand of reedgrass (Phragmites communis).

38. Sagemace Bay Island: This colony was on the northeast tip of a forested island in south Sagemace Bay. The colony was situated on a rocky spit extending about 15 m off the tip of the island. On 19 June 1988, 141 nests were present. Most nests contained eggs or newly hatched chicks.

There were 153 pairs of cormorants nesting on this island in 1989. There were no signs of human disturbance, but three nests were abandoned.

Net Point: Pelicans were observed in the forest and along the shoreline of Net Point during the 9 May 1988 visit to Hay and Sugar Island reefs. On 31

May we visited the Net Point colony and counted 927 pelican and 358 cormorant nests. The colony extended well into the forest (approximately 35 m). Most nests contained eggs. Predation, likely by crows, appeared to be significant at peripheral nests along the southeast section of the colony. Approximately 100 pelican eggs were predated or displaced. Crows nested in the trees above the colony. Two Black-crowned Night Heron nests were also found. Our census took 30 min to complete. However, adult pelicans did not return to the colony until at least 45 min after we left.

This colony was visited again on 2 July 1988, when 229 mobile cormorants and 207 mobile pelicans were present. Pre-fledging success for pelicans and cormorants was 0.2 and 0.6, respectively. Nine cormorant chicks with bill deformities were found.

Population trends

The number of cormorant nests on Lake Winnipegosis dropped 12% from 35,191 in 1987 to 30,857 in 1988. Cormorant nest numbers then increased by 68% to 51,759 nests in 1989. The total number of cormorants, including nonbreeding birds, was estimated to be 77,400 in 1987, 67,900 in 1988 and 113,900 in 1989. Despite large increases in cormorant numbers between 1988 and 1989, the number of colonies remained the same; there were 37 cormorant colonies in 1987 and 38 in 1988 and 1989. Between 1987 and 1988, there were declines in 63% of cormorant colonies. Between 1988 and 1989, cormorant number declines occurred on 31% of the colonies. This demonstrates that declines in the number of breeding pairs occurred on many colonies despite a population increase in 1989.

There were 3,719 pelican nests on Lake Winnipegosis in 1987, 3,750 in 1988 and 5,939 in 1989. Whereas 9 colonies were used by pelicans in 1987, 7 and 10 were used in 1988 and 1989 respectively. The total number of pelicans, including nonbreeders, was approximately 8,200 in 1987, 8,300 in 1988 and 13,100 in 1989. Most pelicans nested on one of three colonies. In 1989, three new colonies, containing 2-5 pelicans, were established.

Ring-billed Gulls were the most abundant gull species nesting on Lake Winnipegosis. They were found on 7 colonies in 1987 and 11 colonies in 1989. In 1987, 532 Herring Gull nests were found on 26 islands and reefs. Numbers declined to 119 nests on 20 colonies in 1989. Colonies were small, containing 1-50 nests. There were 822 California Gull nests on 6 colonies in 1987. Common Terns were found on 6 colonies in 1987 and 5 in 1989. There were 2763 Caspian Tern nests on 5 colonies in 1989. The number of Great Blue Heron nests on Lake Winnipegosis declined from 143 in 1987 to 62 in 1989. There were 16 Black-crowned Night Heron nests on 3 colonies in 1989.

Human disturbance of colonial waterbirds

Human activities on the breeding colonies of Lake Winnipegosis have been primarily directed toward cormorants and, to a lesser extent, other waterbird species. Cormorant nests containing eggs or newly-hatched young were normally crushed underfoot, while older young were clubbed or strangled. On Bachelor's Island, which contained 1,286 cormorant nests and 80 gull nests in 1989, the

eggs and young of all species were thrown into the water. In 1988, a flame thrower was used to destroy 500 cormorant nests on Gobbler Island. In addition to destroying young, many adult birds that congregated around breeding colonies were shot.

In 1987, 41% of all cormorant colonies were disturbed by humans (Table 3). This seriously affected their reproductive success: an estimated 9,900 young that would have fledged were killed in 1987. In 1988, 5 colonies were known to have been disturbed by humans. In 1989, 29% of all cormorant colonies were disturbed (Table 3). Disturbance took place on extremely large colonies. As a result of human activity, 43,200 cormorants did not fledge in 1989. While older young were normally clubbed to death, many nests were destroyed by people who stepped on hatchlings and eggs. Natural Resource Officers surveyed many of the cormorant colonies in 1990. They found a minimum of 11,050 nests destroyed on 5 islands and reefs. Some birds had renested.

The reproductive success of pelicans was estimated in 1989. Nearly 80% of all pelicans nested on breeding colonies disrupted by humans (Table 4). Productivity was low on these colonies: approximately 1,400 pelican young did not fledge as a result of human disturbance. Herons, gulls and terns were present on 55% of the colonies that were disturbed. The impact that humans had on these species was not determined.

Cormorant diet

Nearly 11,000 regurgitates were collected from cormorants during 1987 and 1988 (Table 5). Yellow perch were numerically the most important prey item; these were mostly in the 5-15 cm size range. White suckers were also abundant, predominately in the 23-35 cm size and hence constituted an equally important prey item by weight. In contrast, commercially valuable fish such as walleye and sauger were insignificant components of the diet of either cormorants or pelicans. Numerically, walleye and sauger comprised less than 0.3% of the total prey base.

Preliminary analysis of prey by season suggests that size of prey items increase as the chicks mature but that prey composition does not change appreciably. It was noted that tullibees were more numerous at colonies in the northern half of the lake and in Dawson Bay than in the southern half of the lake. There was no evidence that species prey selection changed significantly during the pre-migration period.

Pelican diet

Over 200 regurgitates were collected from pelicans during 1989 (Table 6). Sticklebacks were the most common fish species found in the diet of pelicans. The mean fork length for the sticklebacks was one-half of that for yellow perch, which were of secondary importance in the diet of pelicans. comprising a significant proportion of the diet by weight. Suckers were also an important food source, being large in size and thus comprising a significant proportion of the diet by weight.

Table 3. Influence of human disturbance on Double-crested Cormorant productivity (No. fledging x nest^{-1}) on Lake Winnipegosis.

Year	Human disturbance	Total [1] no. nests	Mean ± s.d. no. nests x colony^{-1}	Mean ± s.d. Productivity
1987	Undisturbed	28054 (22)	1275±1047 (22)	1.8±0.9 (19)
	Disturbed	7137 (15)	476±540 (15)	0.4±0.5 (13)
	Total	35191 (37)	951±955 (37)	1.2±1.0 (32)
1989	Undisturbed	26340 (27)	1013±867 (26)	2.1±1.0 (21)
	Disturbed	25399 (11)	2309±2938 (11)	0.4±0.6 (9)
	Total	51759 (38)	1362±1801 (38)	1.6±1.2 (30)

[1] Total number of cormorant nests on islands and reefs where people had not or had destroyed at least one nest (No. colonies in parenthesis)

Table 4. Influence of human disturbance on American White Pelican productivity (No. fledging x nest^{-1}) on Lake Winnipegosis in 1989.

Human disturbance	Total [1] no. nests	Mean ± s.d. no. nests x colony^{-1}	Mean ± s.d. Productivity
Undisturbed	1251 (6)	209±316 (6)	0.7±0.2 (3)
Disturbed	4688 (4)	1172±871 (4)	0.4±0.1 (2)
Total	5939 (10)	594±746 (10)	0.5±0.2 (8)

[1] Total number of pelican nests on islands and reefs where people had not or had destroyed at least one cormorant nest (No. colonies in parenthesis)

Table 5. Composition of prey species found in regurgitation samples of Double-crested Cormorants from Lake Winnipegosis in 1987 and 1988.

Species	N	Length $\bar{X}$ (mm)	Length SE (mm)	% Frequency	% Weight
Yellow Perch	6790	100	0.7	62.2	27.4
White Sucker	1179	224	2.6	10.8	46.5
Tullibee	1440	149	1.7	13.2	20.3
Northern Pike	43	259	12.2	0.4	1.5
Walleye	30	94	11.0	0.3	0.2
Sauger	33	205	21.0	0.3	0.3
Troutperch	476	83	1.5	4.4	0.8
Burbot	48	280	14.7	0.4	1.8
Spottail Shiner	403	70	3.6	3.7	0.5
Emerald Shiner	173	77	2.9	1.6	0.1
Brook Stickleback	51	53	1.5	0.5	0.1
9-sp. Stickleback	142	51	0.9	1.3	0.03
Stickleback spp.	3	-	-	0.02	<0.01
Logperch	60	70	3.5	0.5	0.1
Black-sided Darter	3	56	-	0.02	<0.01
Iowa Darter	2	37	-	0.02	<0.01
Darter spp.	7	47	-	0.1	<0.01
Fathead Minnow	8	56	2.3	0.1	<0.01
Whitefish	1	-	-	<0.01	0.1
Crayfish	19	-	-	0.2	0.02
Total	10911			100.1	99.8

Table 6. Composition of prey species found in regurgitation samples of American White Pelicans from Lake Winnipegosis in 1989.

Species	N	Length $\bar{X}$ (mm)	Length SE (mm)	% Frequency
Yellow Perch	62	88	6.6	30.1
White Sucker	10	380	10.2	4.9
Northern Pike	2	347	-	1.0
Walleye	1	-	-	0.5
Sauger	1	340	-	0.5
9-sp. Stickleback	91	43	0.6	44.2
Crayfish	23	-	-	11.2
Dragonfly larvae	16	-	-	7.8
Total	206			100.2

DISCUSSION

Population trends

The largest breeding populations of cormorants in Manitoba have traditionally occurred on Lake Winnipegosis (Bent 1922, Vermeer 1969, Koonz and Rakowski 1985). McLeod and Bondar (1953) recorded 9,862 cormorant nests in 1945 and 4,656 nests in 1951. Declines in cormorant numbers continued until 1969, when 12 colonies were found containing 1,403 nests (Vermeer 1969). From 1987 to 1989, an average of 39,269 nests were present on 38 Lake Winnipegosis colonies. Cormorant numbers decreased from 1987 to 1988 and increased dramatically in 1989.

The number of American White Pelicans increased during the period of study. The number of nests found in 1989 was comparable to the 4,632 found on 8 colonies in 1986 (Koonz 1987). The present report is the only one giving breeding numbers for gulls and herons. In the late 1970's, the Canadian population of Caspian Terns was estimated at 5,149 pairs. There were approximately 1220 Caspian Tern nests counted on Lake Winnipegosis at that time. Numbers of Caspian Terns have since increased and Lake Winnipegosis supports the largest population of any lake in Canada.

Human disturbance

Commercial fishermen have for many years destroyed eggs, nestlings and adult cormorants. From 1987 to 1989, many cormorant colonies were partly or totally destroyed by humans. These colonies contained as many as 8 different waterbird species. The productivity of cormorants and pelicans was greatly reduced on disturbed colonies. The amount of recorded disturbance increased from 1987 to 1989; the colonies disturbed by humans in 1989 contained nearly 5 fold more nests than those disturbed in 1987.

Diet

White Sucker, Yellow Perch and Tullibee were the most important species in the diet of cormorants; these 3 species comprised 86% and 94% of the cormorant diet by frequency and weight, respectively. Walleye and Sauger comprised a negligible proportion of their diet. These values differ from the food composition of cormorants in the 1940's. McLeod and Bondar (1953) discovered that the percentage, by weight, of fish in the cormorant diet was: tullibee (55.7%), yellow perch (31.3%), walleye (6.5%) and goldeye (0.7%).

Changes in the composition of the cormorant diet is reflected in shifts in the Lake Winnipegosis fish community from percid dominance to pike dominance (Lysack 1988). In the early 1930's, walleye comprised 65% and suckers 8% of the commercial catch. By 1950, walleye comprised only 28% and sucker 40% of the commercial catch. Walleye yields peaked from 1950 to 1960, suddenly crashed in 1964 and have remained low to this date. Experimental gill netting operations in 1987 revealed that 20% and 63% of all catches were composed of walleye and sucker, respectively (Lysack 1988).

SUMMARY

Lake Winnipegosis is one of the most productive lakes in Canada for colonial waterbirds. Nine different waterbird species nest together on roughly 50 of the islands and reefs of this shallow lake. Cormorants are the most abundant waterbird species. Their numbers increased during the study period and particularly over the previous 20 years. High cormorant numbers have been a growing concern among commercial fishermen from Lake Winnipegosis for many years. These fishermen blame cormorants for declines in yields of commercially valuable species such as walleye and consequently destroy cormorant eggs, nestlings and adult cormorants annually.

The present study shows that the productivity of both cormorants and pelicans was significantly lower in colonies disturbed by humans. Herons, gulls and terns were also affected by humans and nested in 55% of the disturbed colonies. Cormorants and pelicans are protected in Manitoba under the Wildlife Act; herons, gulls and terns are protected under the Migratory Bird Convention Treaty. There was no evidence that cormorants caused significant declines in commercial fish stocks. Cormorants are opportunistic but feed almost exclusively on forage fish of little or no commercial value.

LITERATURE CITED

Bayer, R. D. 1989. The cormorant/fisherman conflict in Tillamook County, Oregon. Studies in Oregon Ornithology No. 6. 101 pp.

Bent, A. C. 1922. Life histories of North American petrels and pelicans and their allies. U.S. National Museum Bulletin 121. 335 pp.

Buckley, P. A. and F. G. Buckley. 1984. Expanding Double-crested Cormorant and Laughing Gull populations on Long Island, New York. Kingbird 34: 146-155.

Craven, S. R. and E. Lev. 1987. Double-crested Cormorants in the Apostle Islands, Wisconsin, USA: Population trends, food habits, and fishery depredations. Colonial Waterbirds 4: 12-19.

Findholt, S. L. 1988. Status, distribution and habitat affinities of Double-crested Cormorant nesting colonies in Wyoming. Colonial Waterbirds 11: 245-251.

Hatch, J. J. 1983. Diet of an expanding population of Double-crested Cormorant. Colonial Waterbirds 6: 71.

Hobson, K. A., R. W. Knapton and W. Lysack. 1989. Population, diet and reproductive success of Double-crested Cormorants breeding on Lake Winnipegosis, Manitoba, in 1987. Colonial Waterbirds 12: 191-197.

Koonz, W. H. 1987. Update status report of the American White Pelican Pelecanus erythrorhynchos. Committee on the Status of Endangered Wildlife in Canada (COSEWIC). 16 pp.

---------- and P. W. Rakowski. 1985. Status of colonial waterbirds nesting in southern Manitoba. Canadian Field-Naturalist 99: 19-29.

Lysack, W. 1988. Lake Winnipegosis fish stock assessment. Manitoba Department of Natural Resources Manuscript Report No. 88-05, Winnipeg.

Markham, B. J. 1978a. Status of the White Pelican (Pelecanus erythrorhynchos) in Canada - 1978. Fish and Wildlife Division Alberta Recreation, Parks and Wildlife Report for Committee on the Status of Endangered Wildlife in Canada (COSEWIC). 27 pp.

---------- 1978b. Status of the Double-crested Cormorant (Phalacrocorax auritus) in Canada. Fish and Wildlife Division Alberta Recreation, Parks and Wildlife Report for Committee on the Status of Endangered Wildlife in Canada (COSEWIC). 28 pp.

McLeod, J. A. and G. F. Bondar. 1953. A brief study of the Double-crested Cormorants on Lake Winnipegosis. Canadian Field-Naturalist 67: 1-11.

Price, I. M. and D. V. Weseloh. 1986. Increased numbers and productivity of Double-crested Cormorants, Phalacrocorax auritus, on Lake Ontario.

Canadian Field-Naturalist 100: 474-482.

Roney, K. and M. Hlady. 1984. 1982 census of Saskatchewan White Pelican and Double-crested Cormorant colonies. Blue Jay 42: 77-82.

Vermeer, K. 1969. The present status of Double-crested Cormorant colonies in Manitoba. Blue Jay 27: 217-220.

---------- 1973. Great Blue Heron and Double-crested Cormorant colonies in the prairie provinces. Canadian Field-Naturalist 87: 427-432.

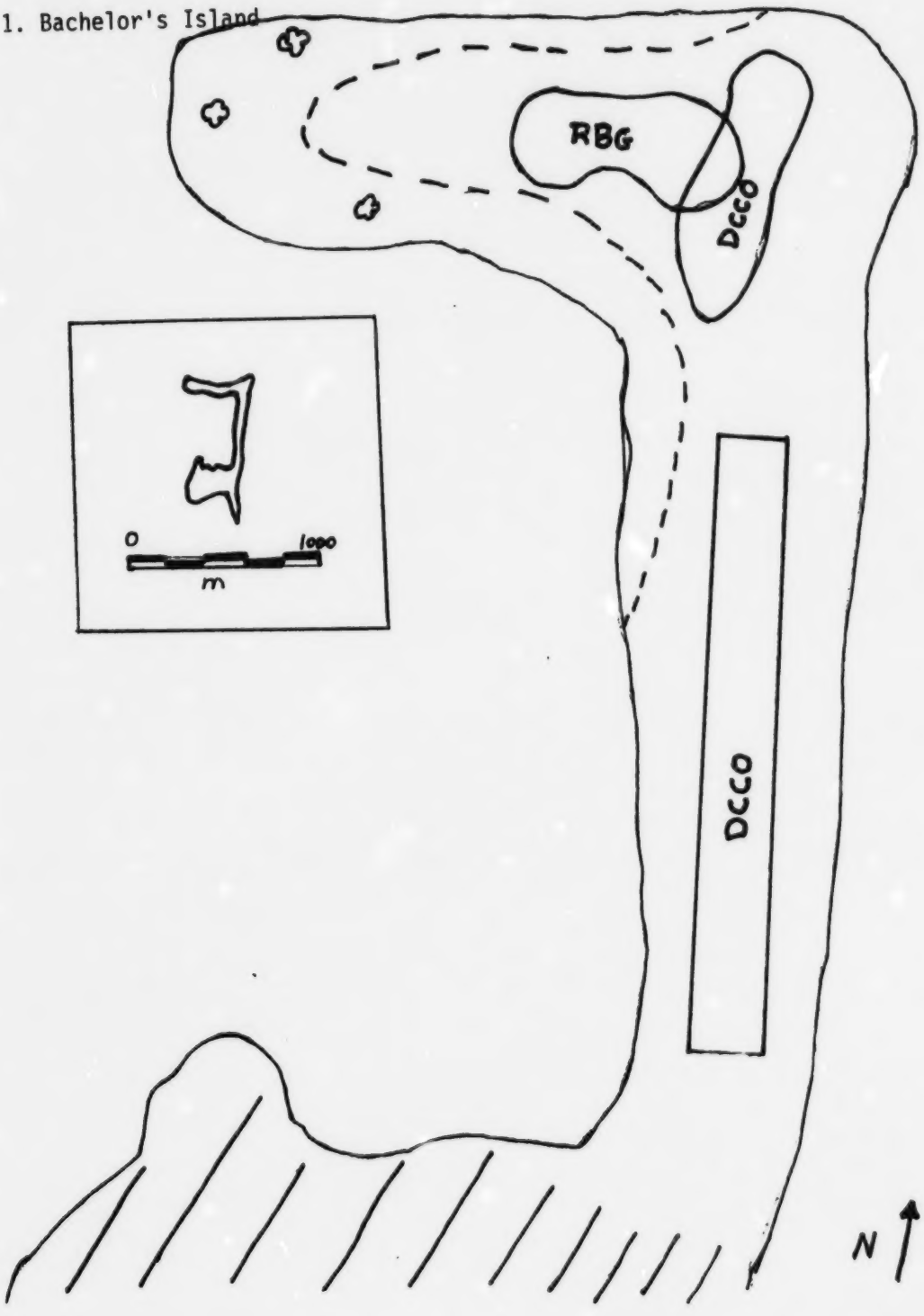
---------- and L. Rankin. 1984. Population trends in nesting Double-crested and Pelagic Cormorants in Canada. Murrelet 65: 1-9.

Weseloh, D. V., S. M. Teeple and M. Gilbertson. 1983. Double-crested Cormorants of the Great Lakes: egg laying parameters, reproductive failure, and contaminant residue in eggs, Lake Huron 1972-2973. Canadian Journal of Zoology 61: 427-436.

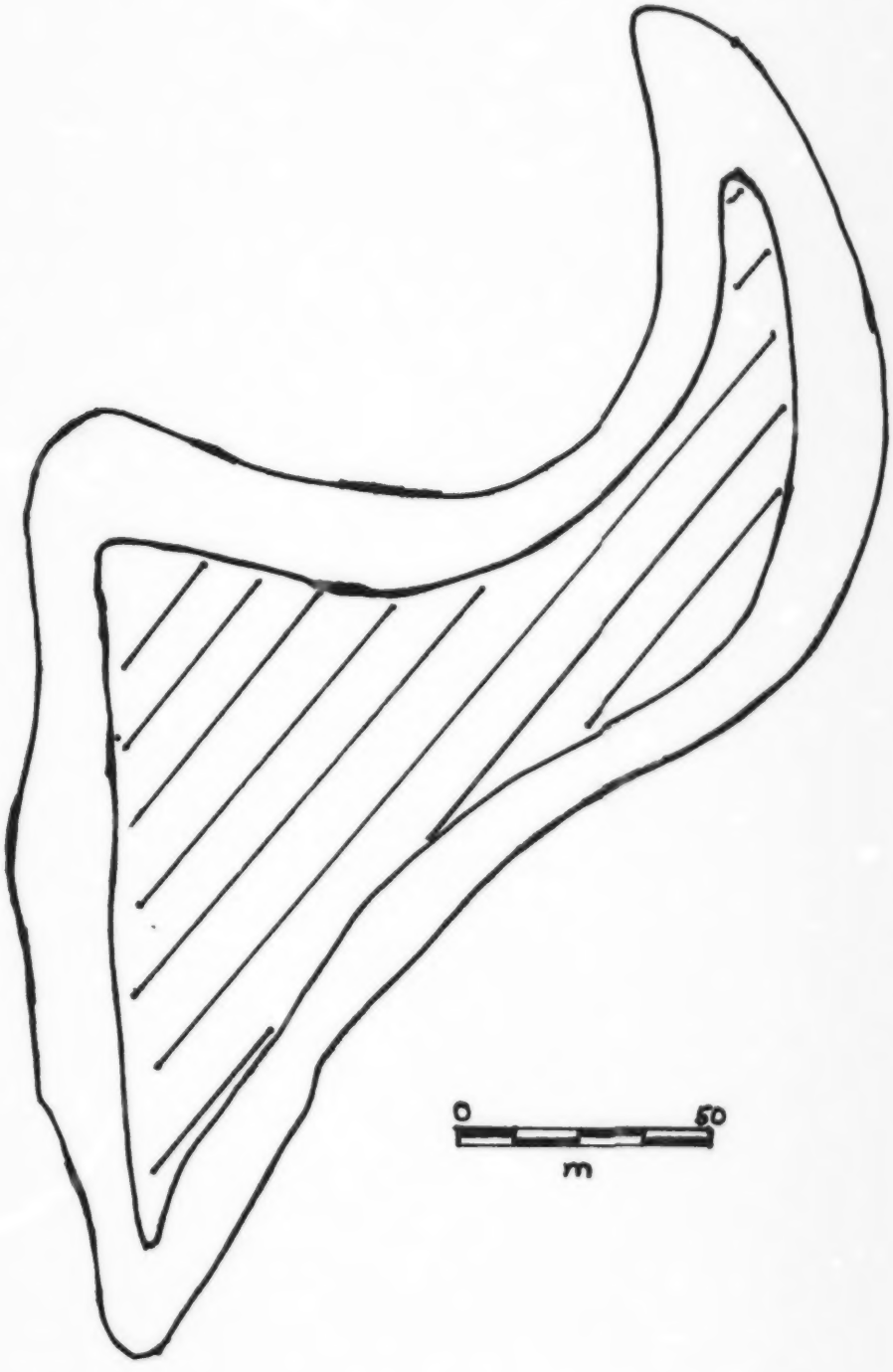
APPENDIX I

Maps of the islands and reefs containing breeding populations of the following colonial waterbirds: American White Pelican (AWP), Black-crowned Night-Heron (BCNH), Great Blue Heron (GBH), Caspian Tern (CT), Common Tern (COT), Double-crested Cormorant (DCCO), Herring Gull (HG) and Ring-billed Gull (RBG). The features presented on the maps include boulders [ ], trees [], forbs [], and marsh plants [].

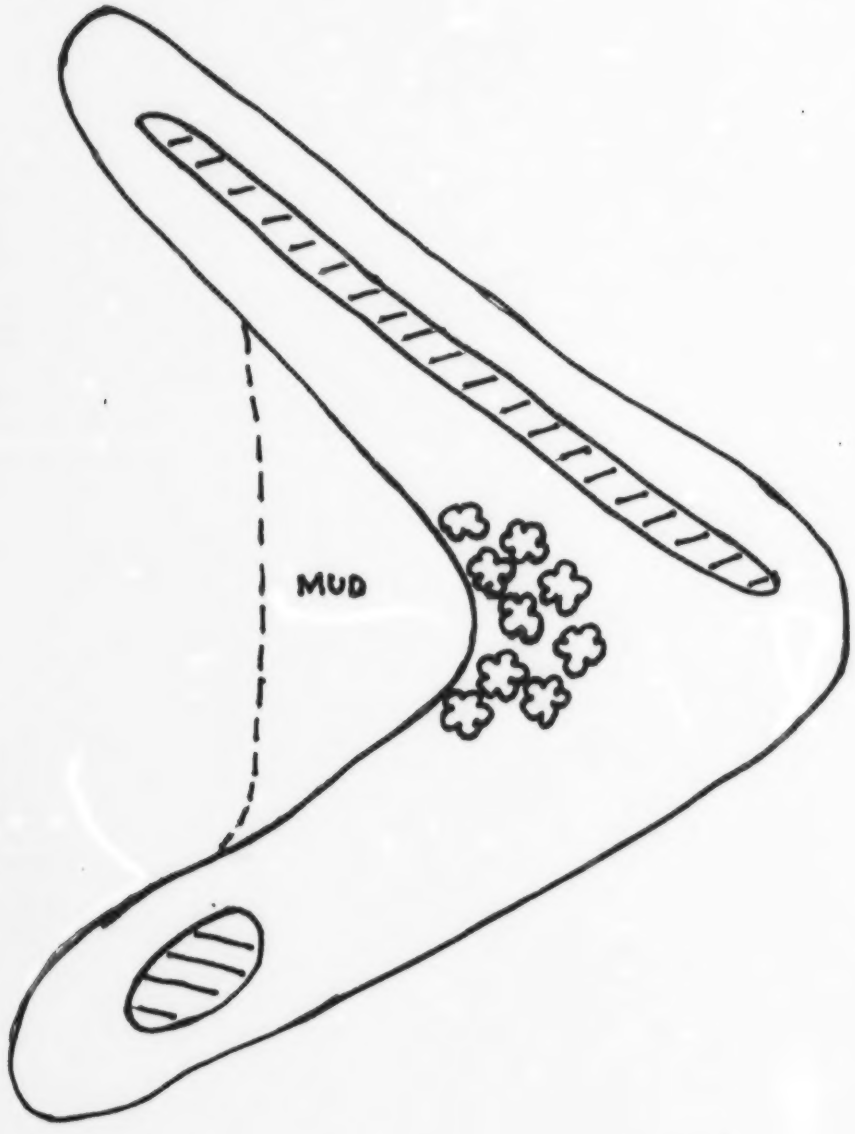
1. Bachelor's Island



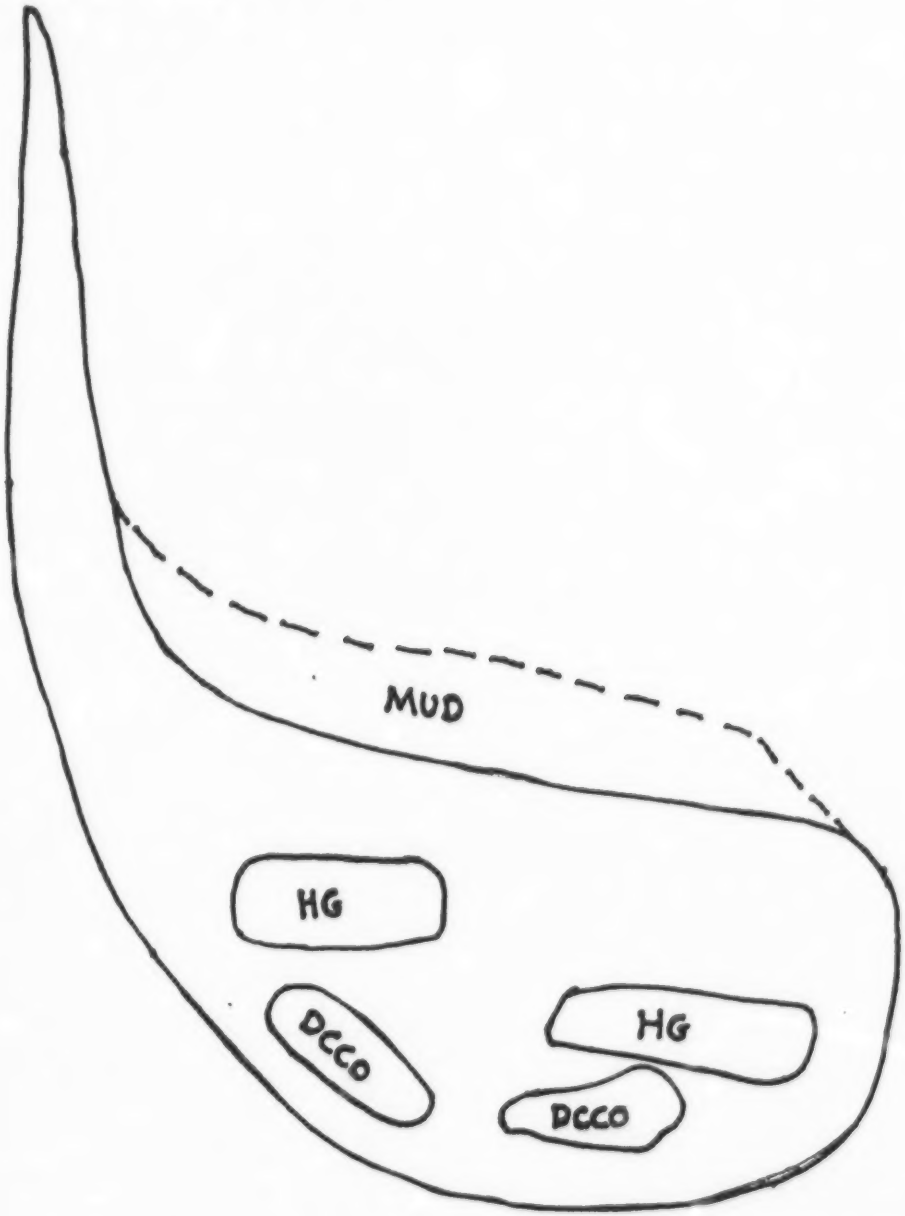
2. Sugar Island Reef



3. Hay Island Reef

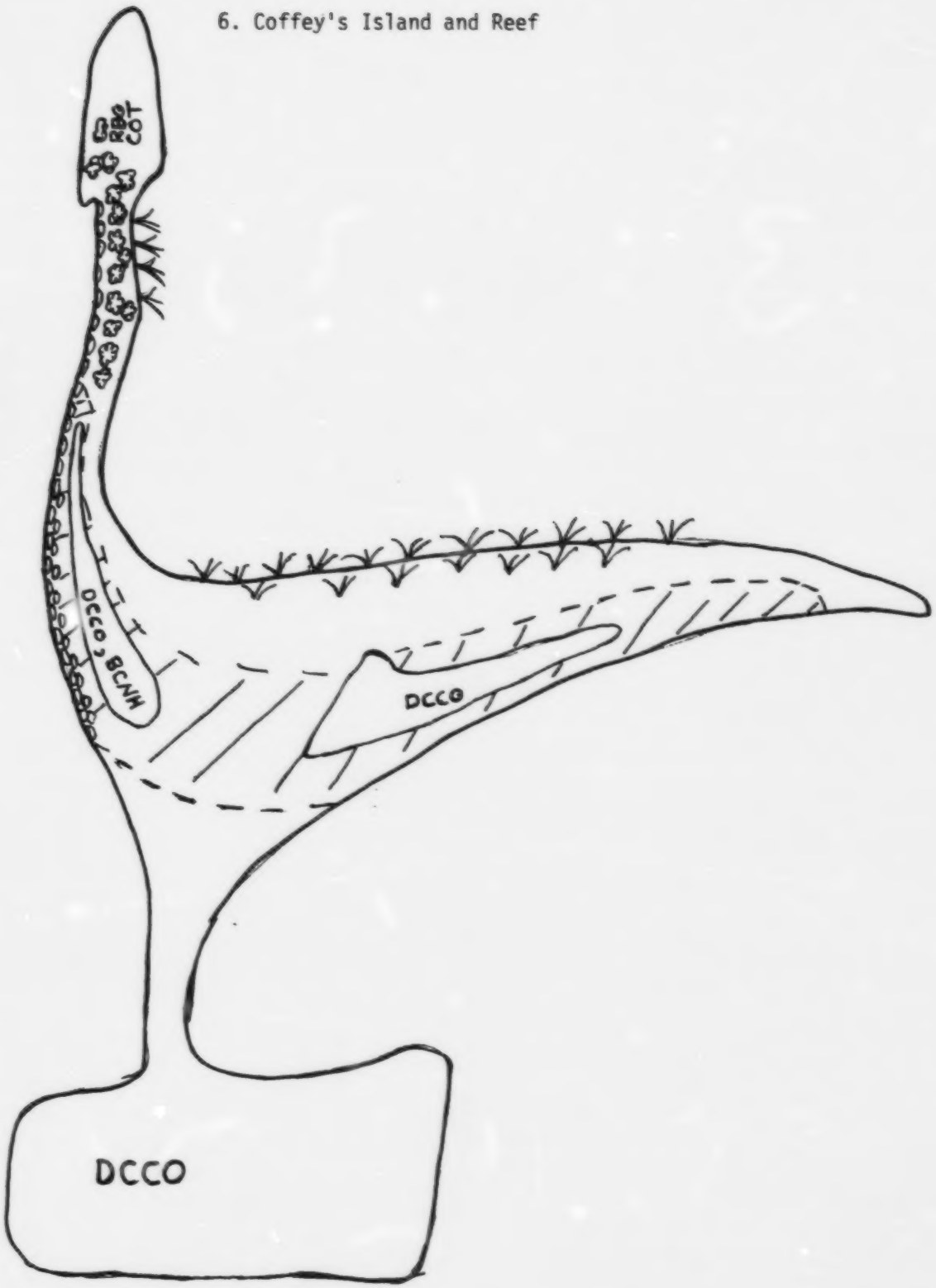


4. Coleman Island



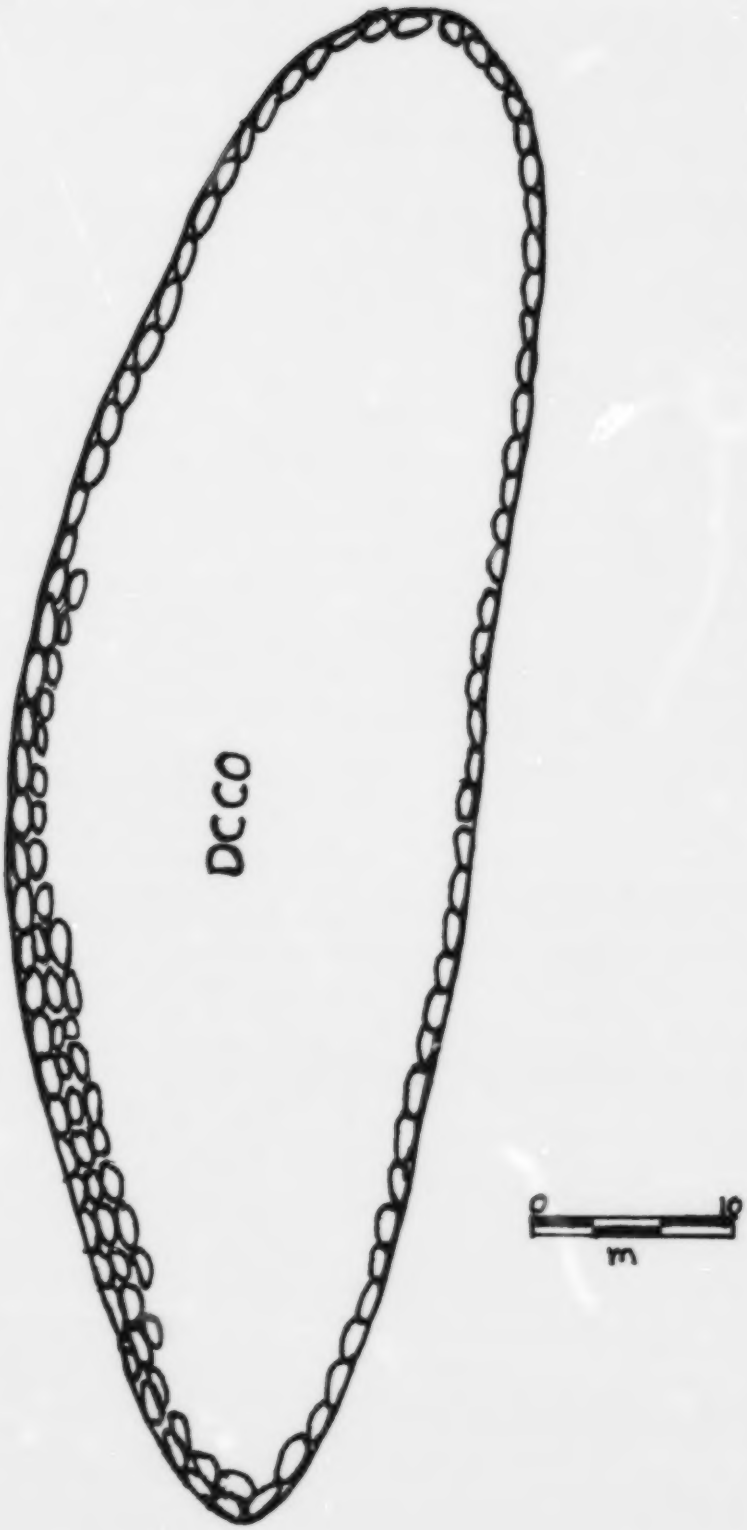
5. Red Deer Point

6. Coffey's Island and Reef

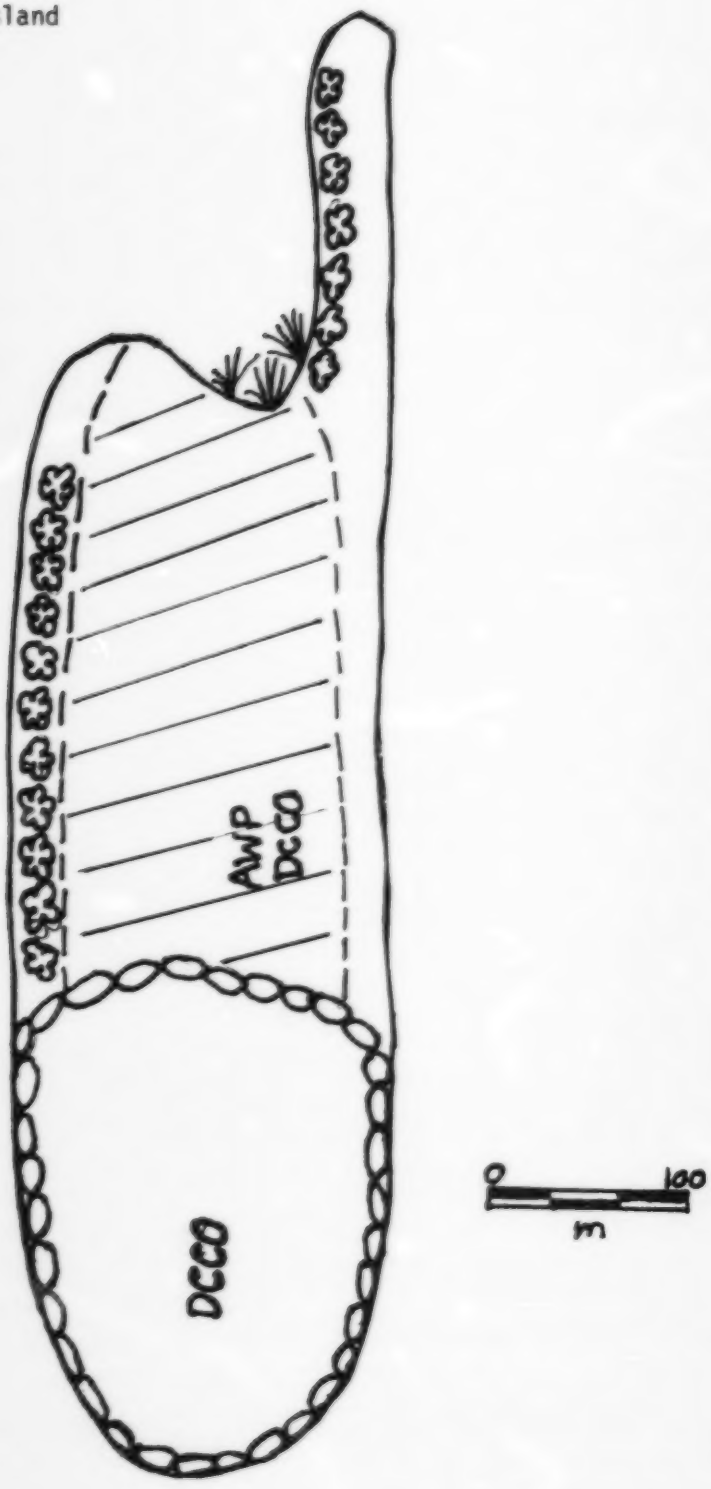


7. Gambler's Point

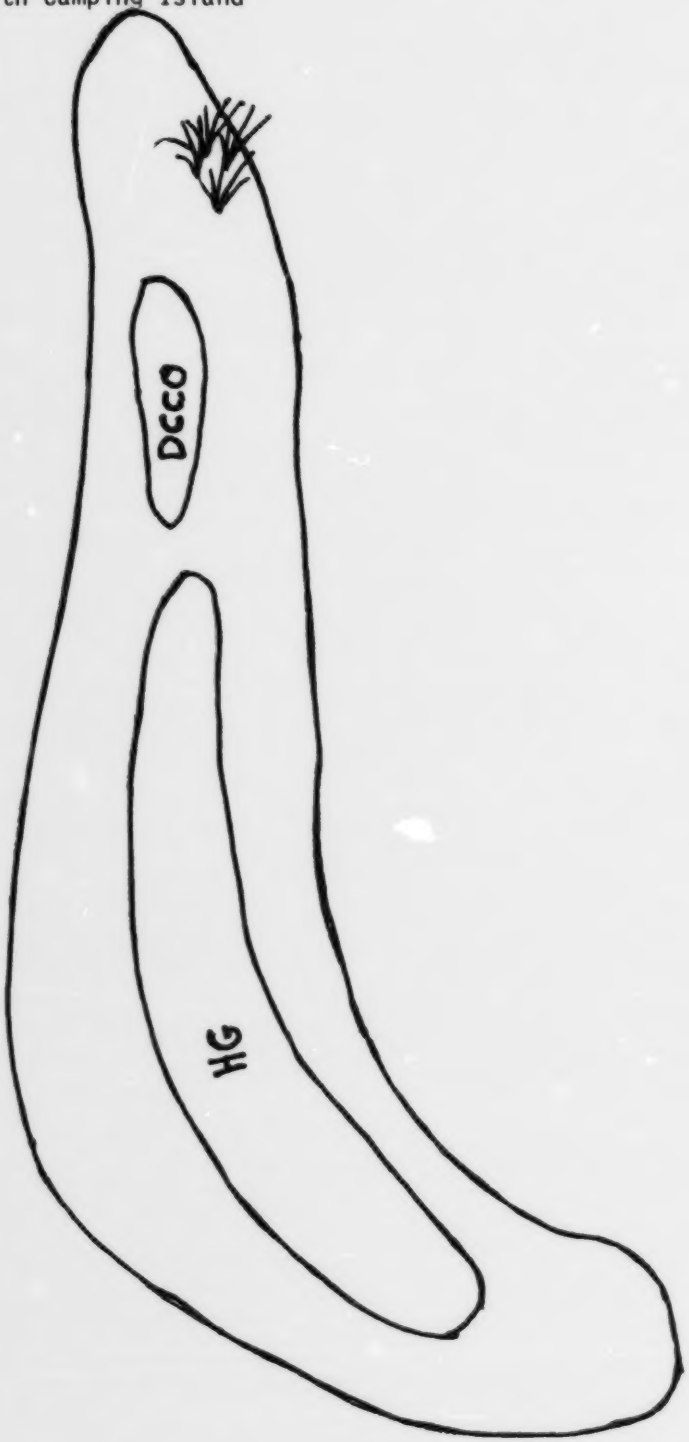
8. Smokey Island



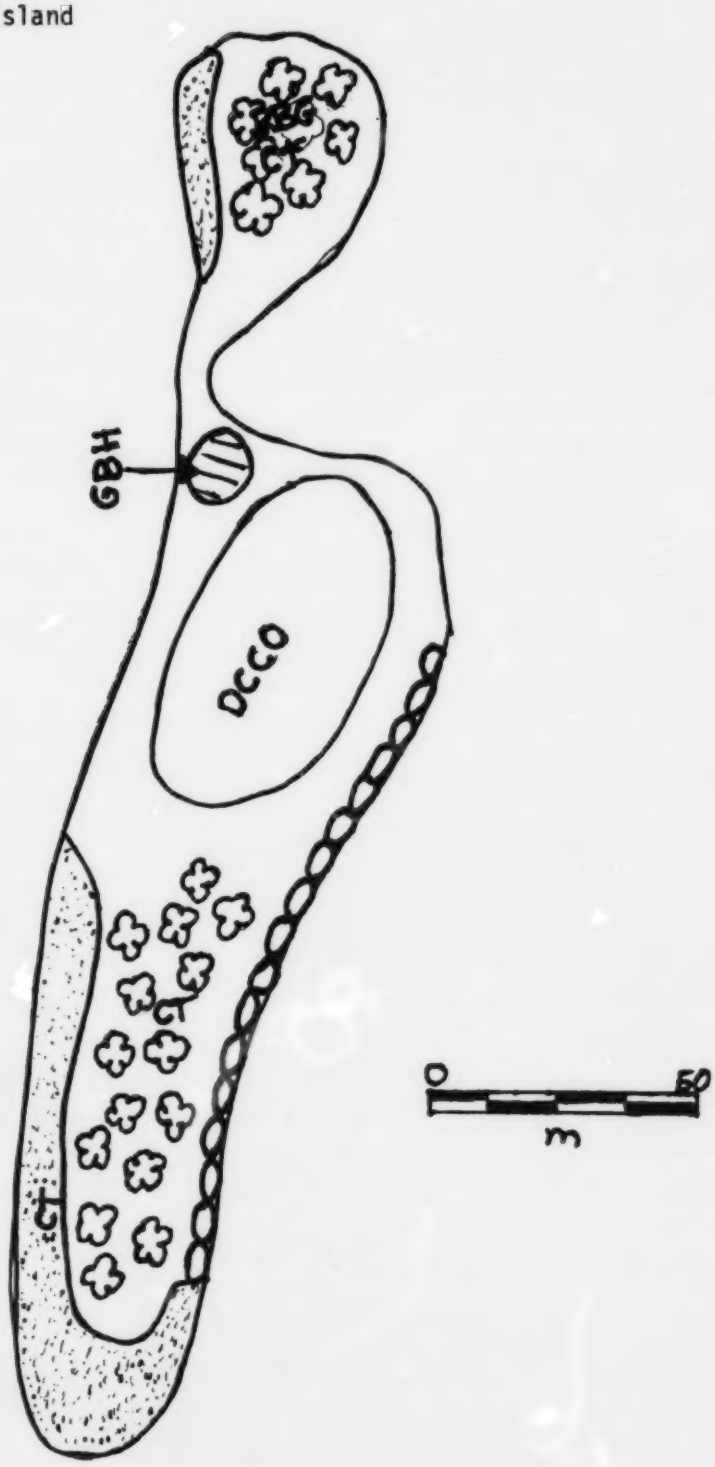
9. South Camping Island



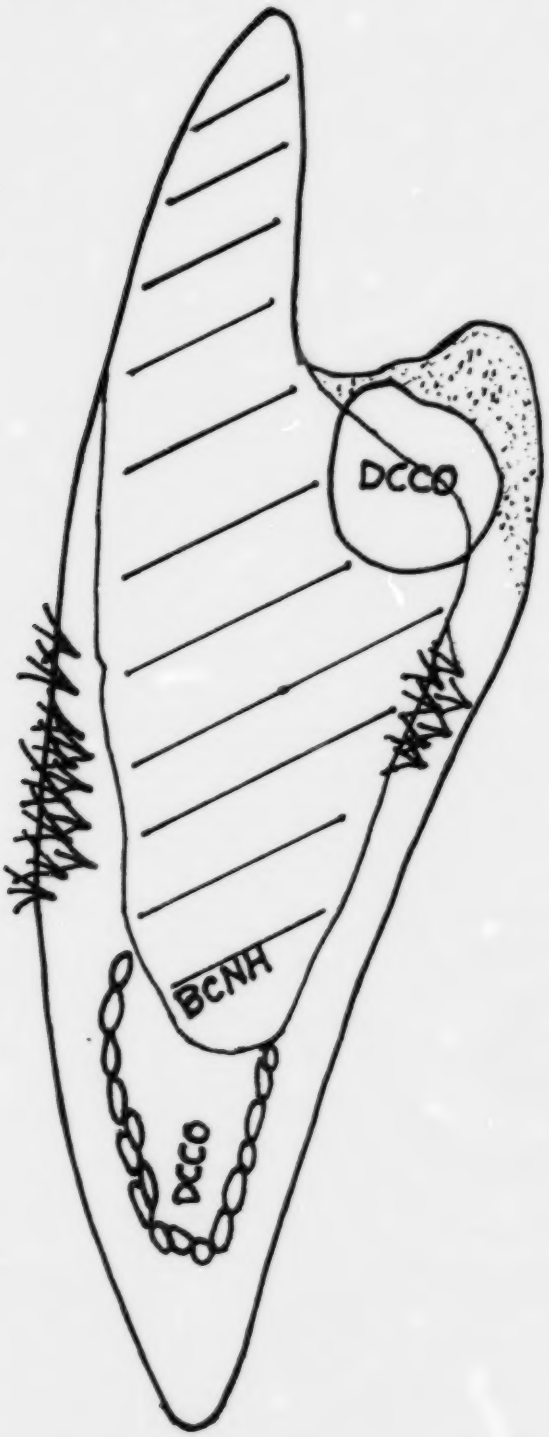
10. North Camping Island



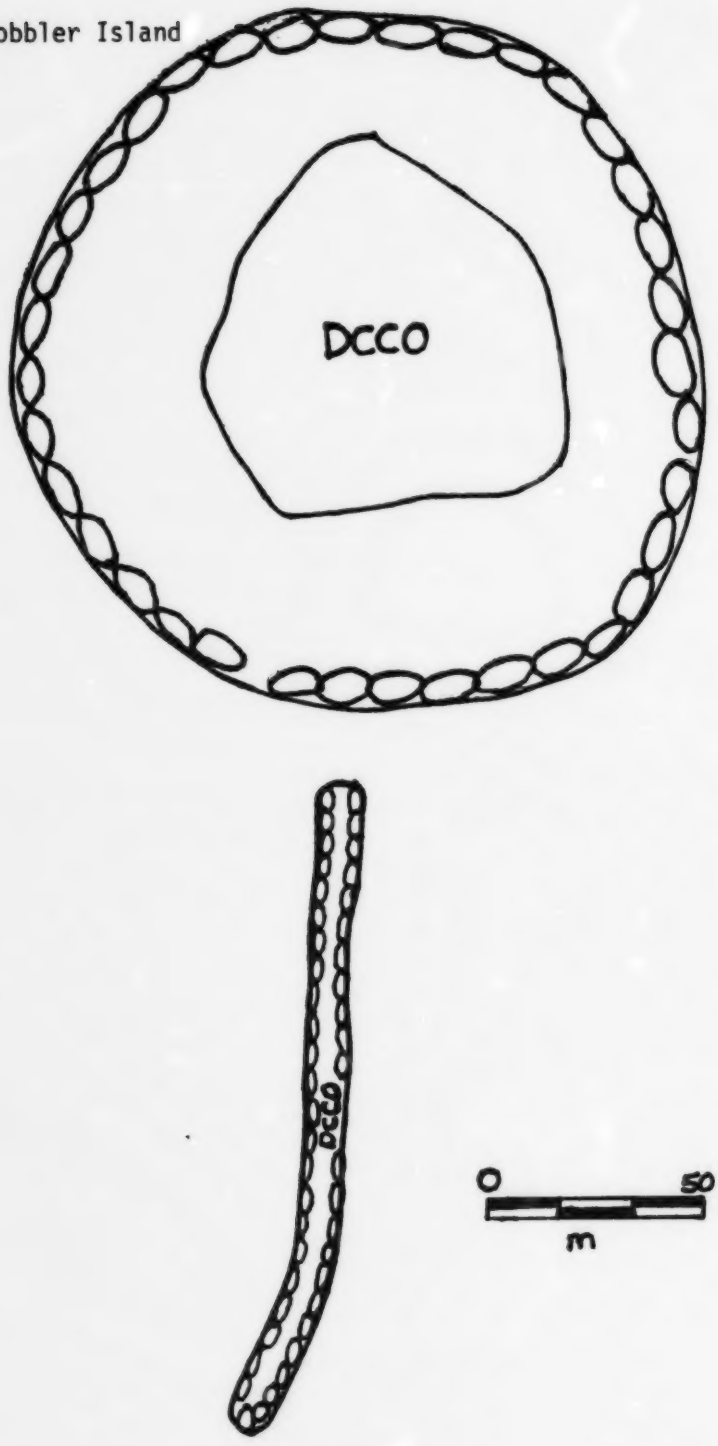
11. Sealey's Island



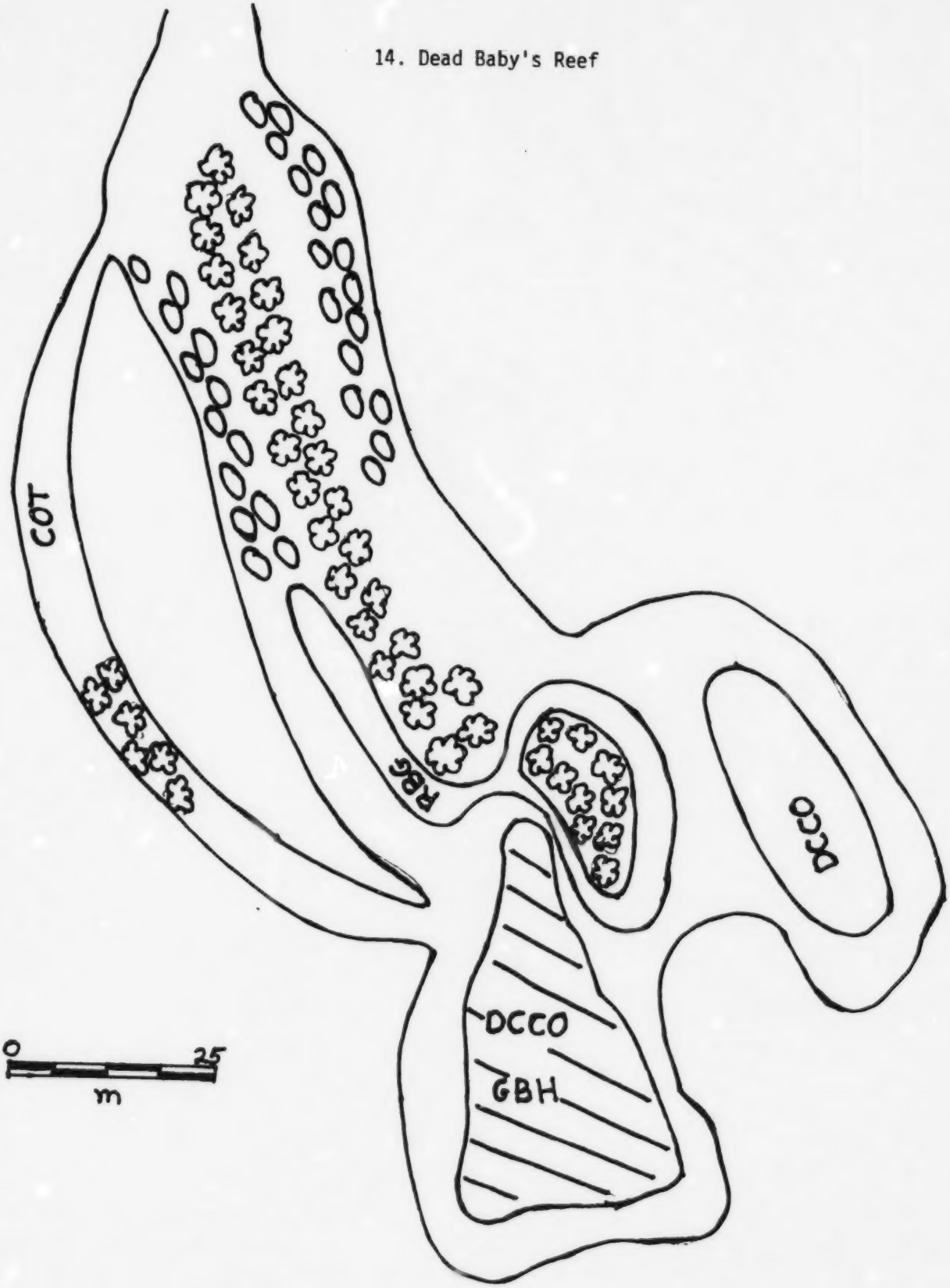
12. Baby Sister's Island



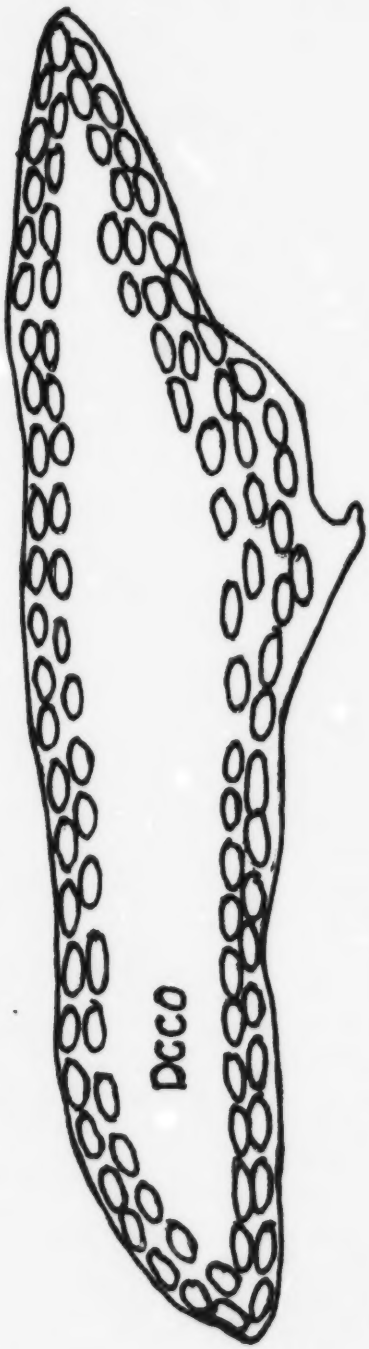
13. Gobbler Island



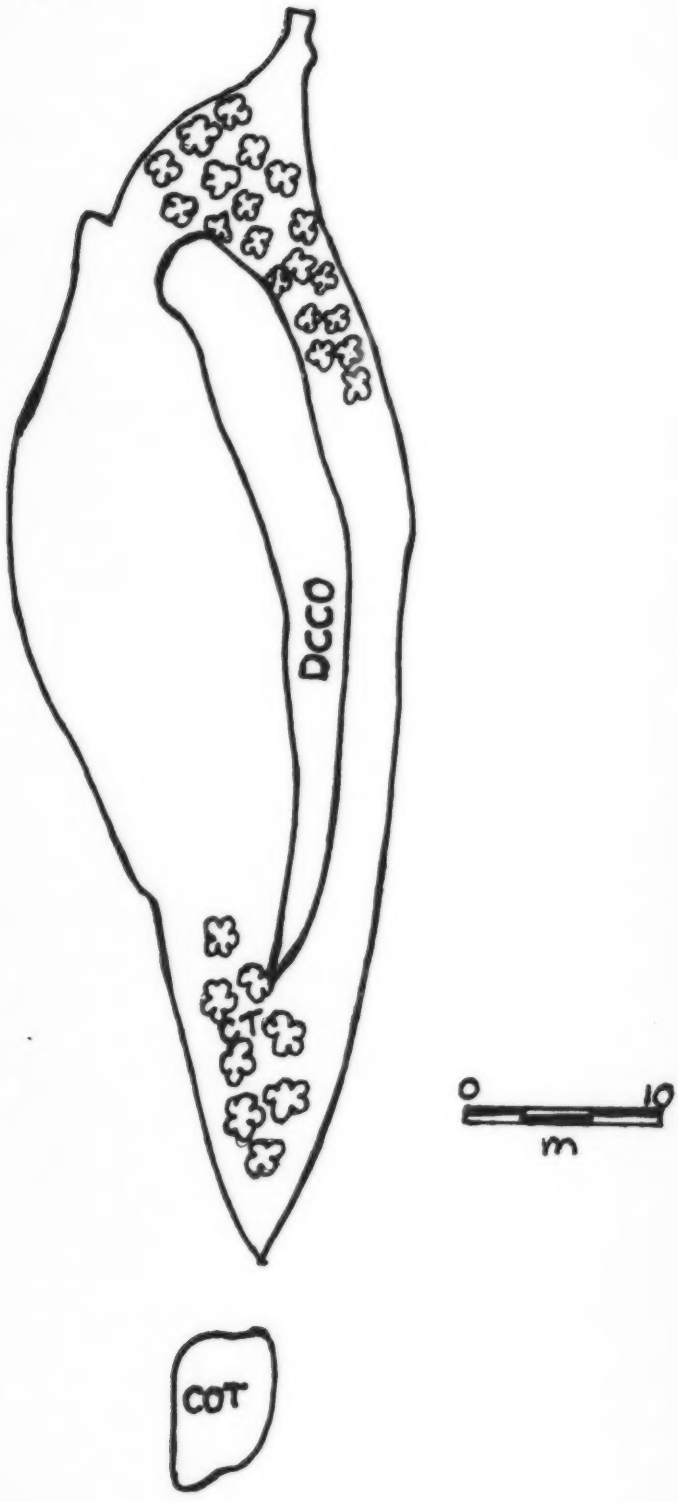
14. Dead Baby's Reef



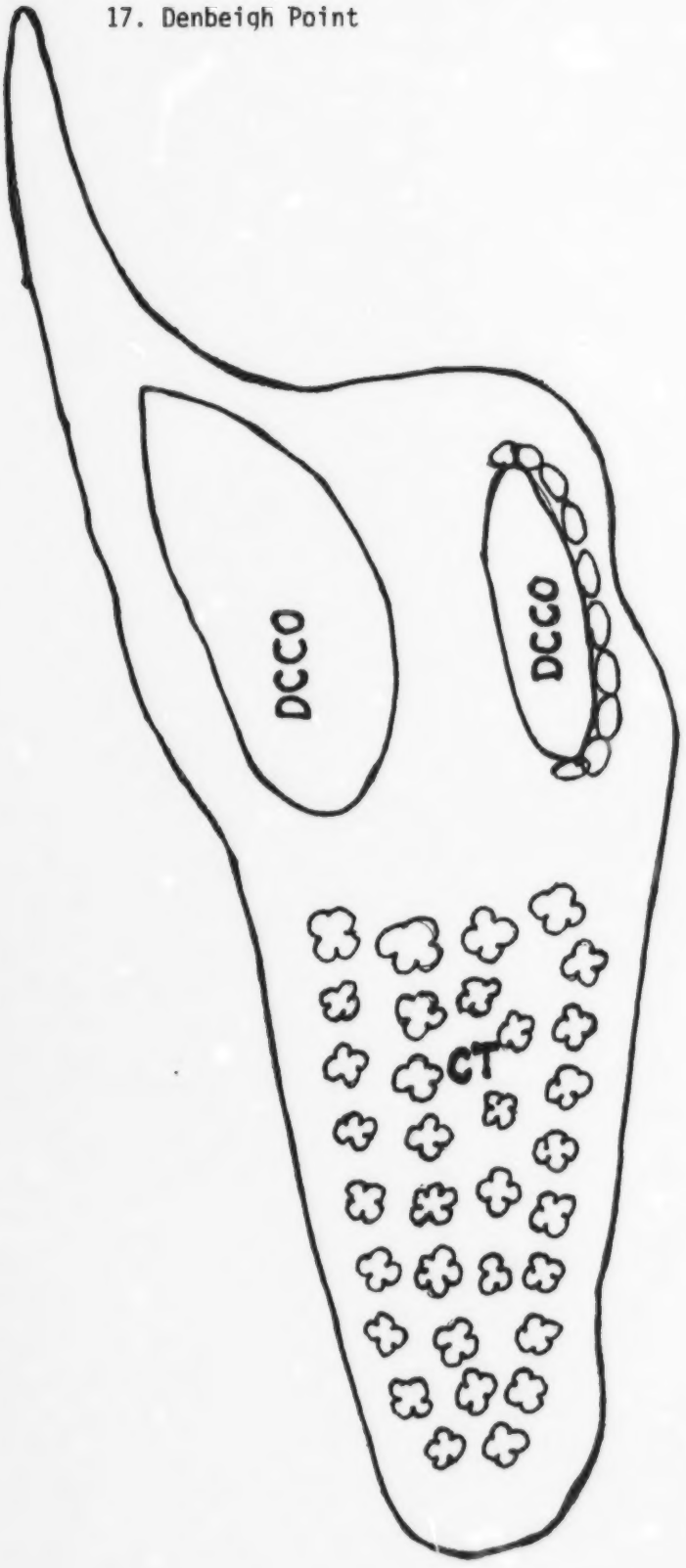
15. South Goose Island



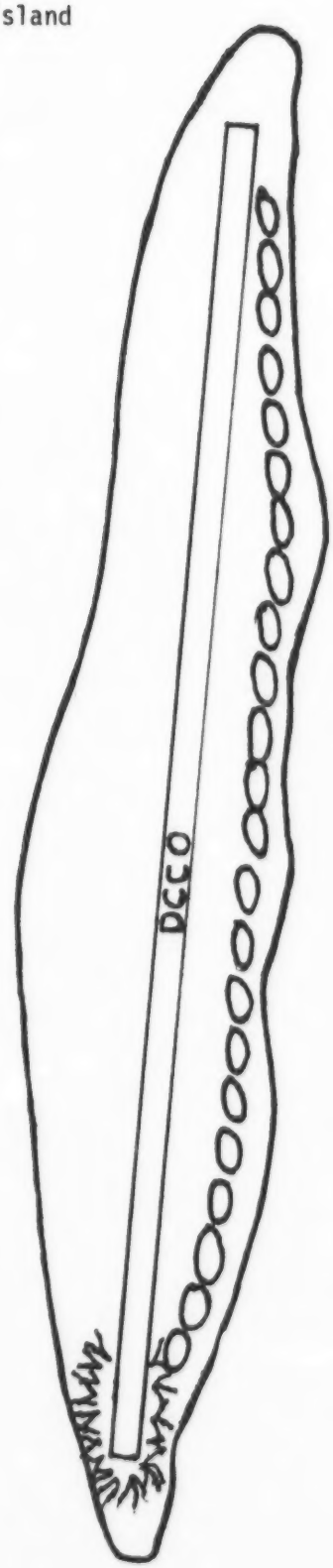
16. North Goose Island



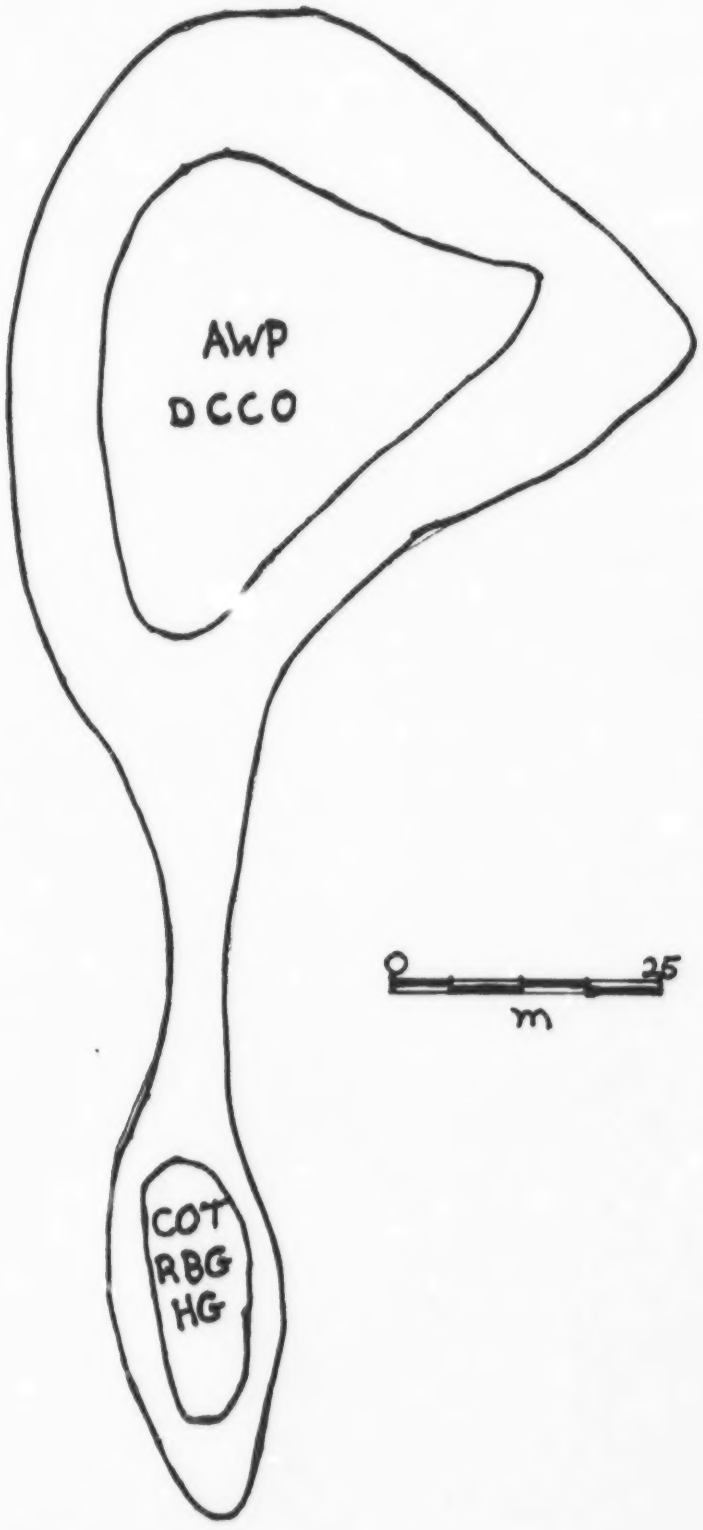
17. Denbeigh Point



18. South Cormorant Island



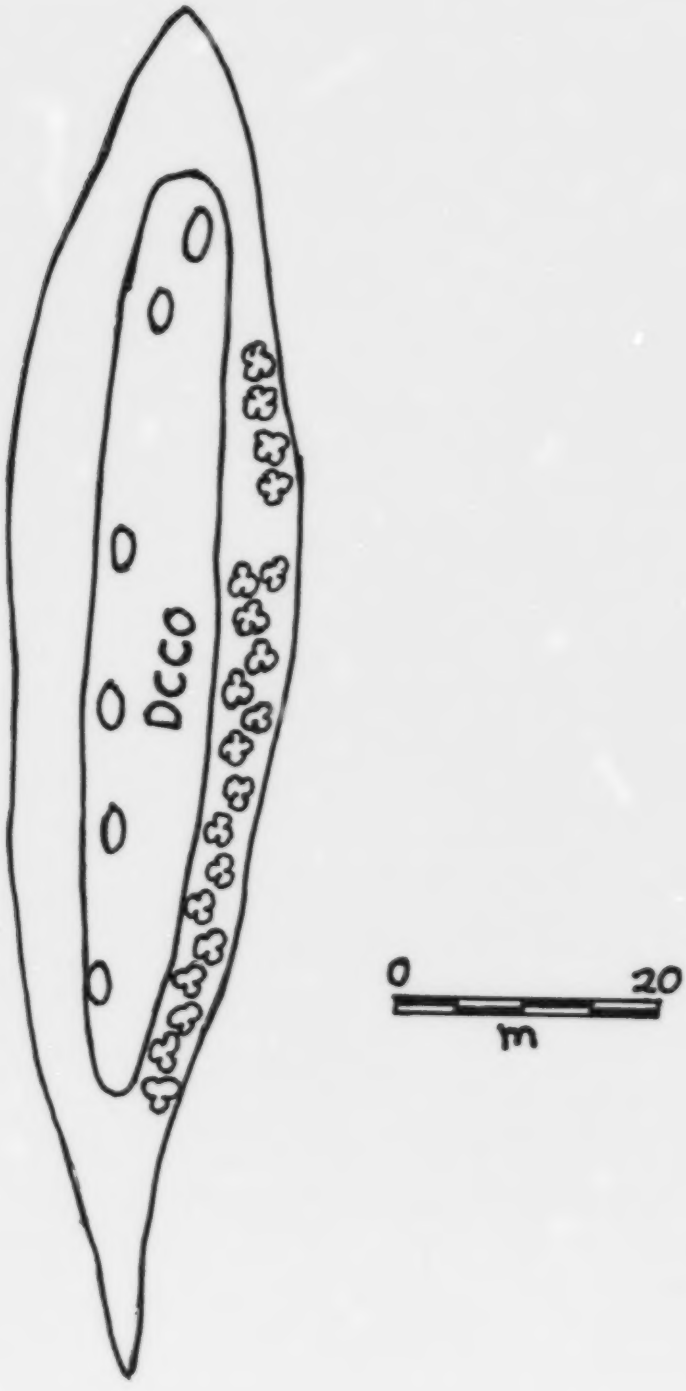
19. North Cormorant Island



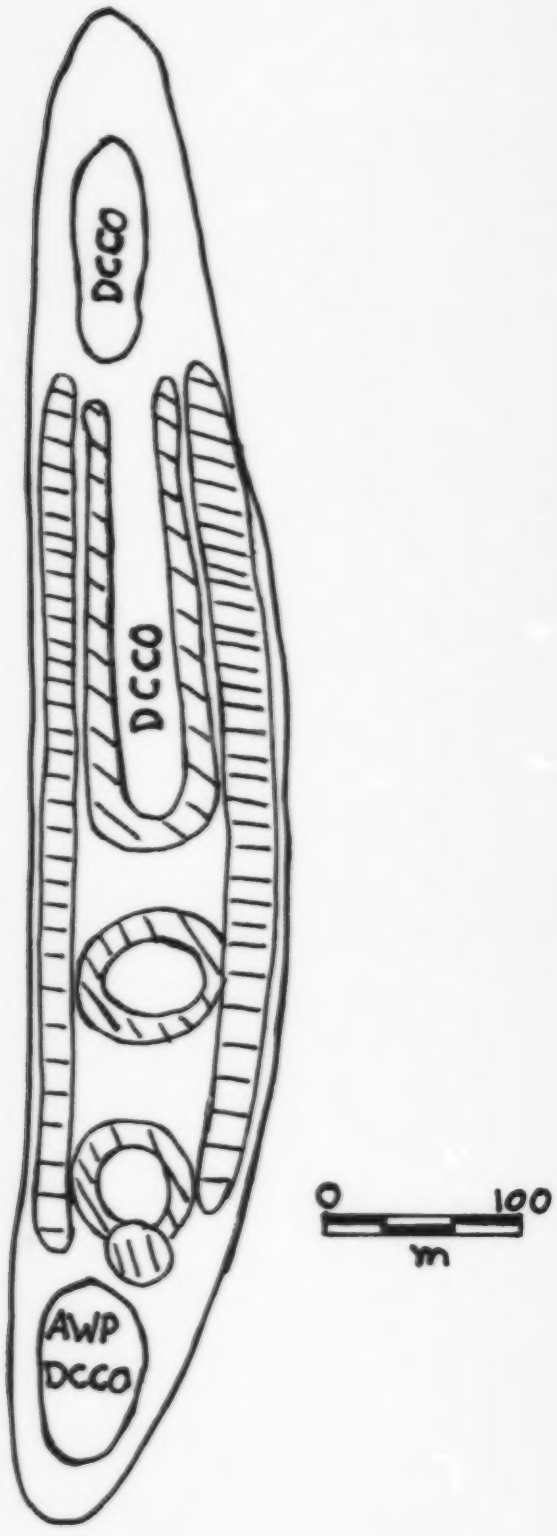
20. Spruce Bluff

21. Whiskey Jack Reef

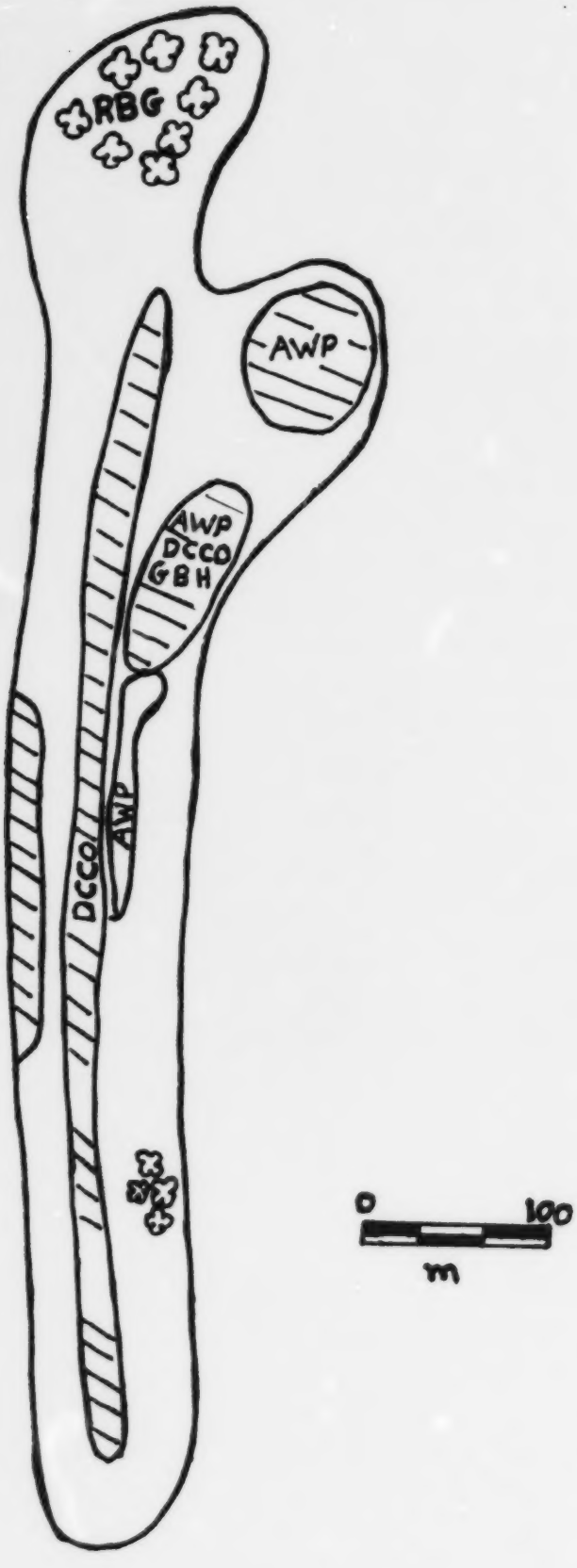
22. South Little Channel Island



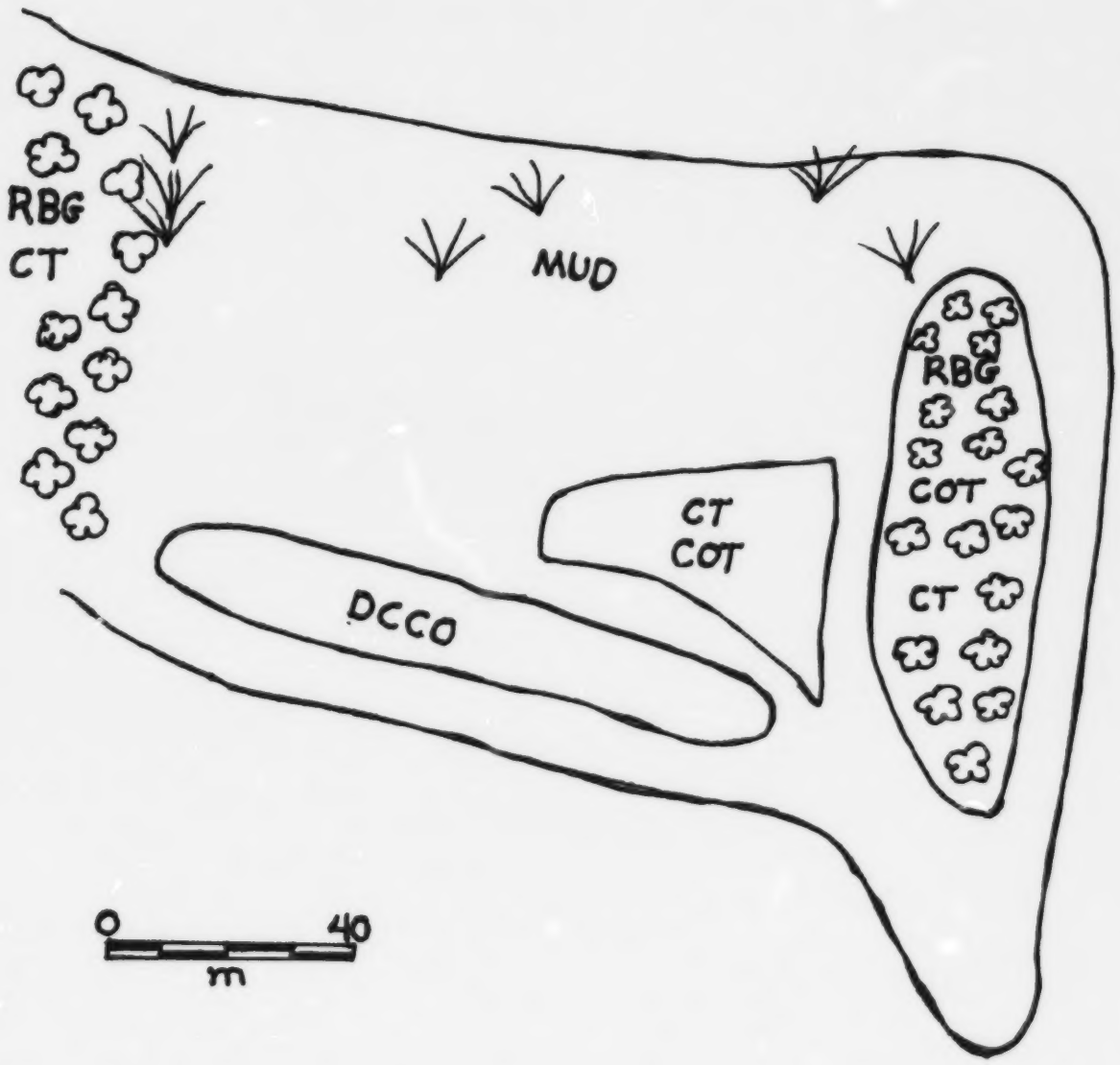
23. Long Island (S)



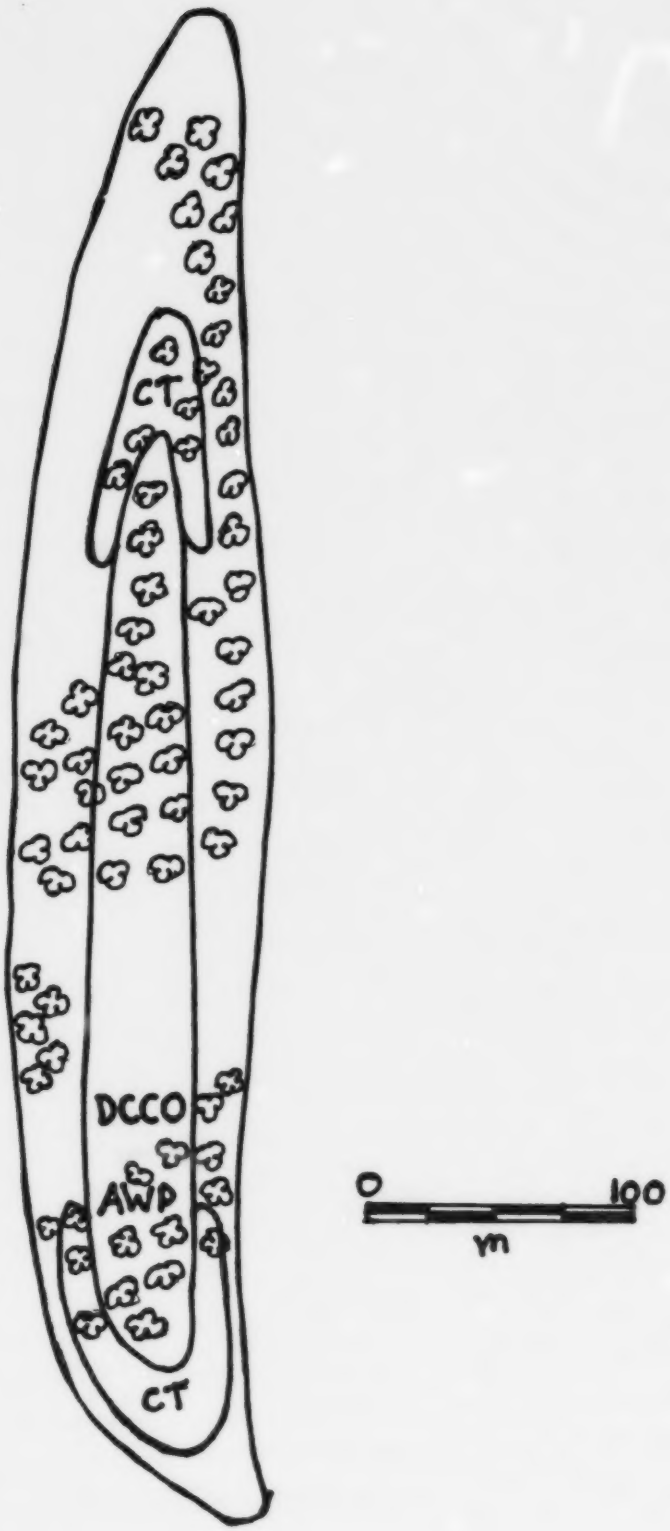
24. Long Island (N)



25. Channel Island (NW)

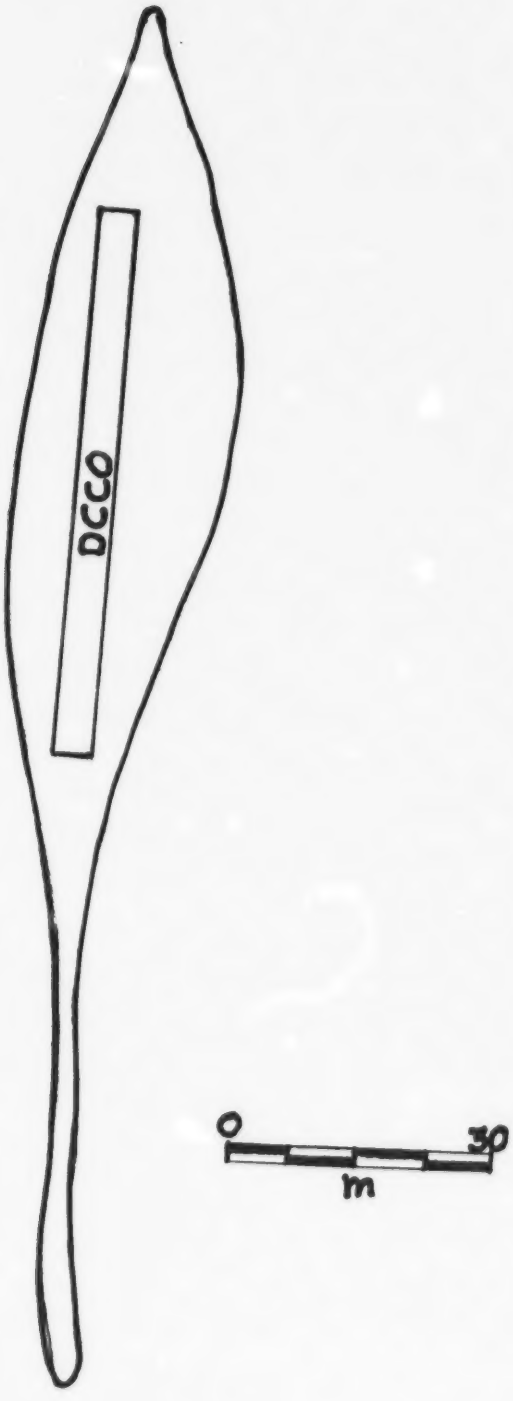


26. Dory's Reef

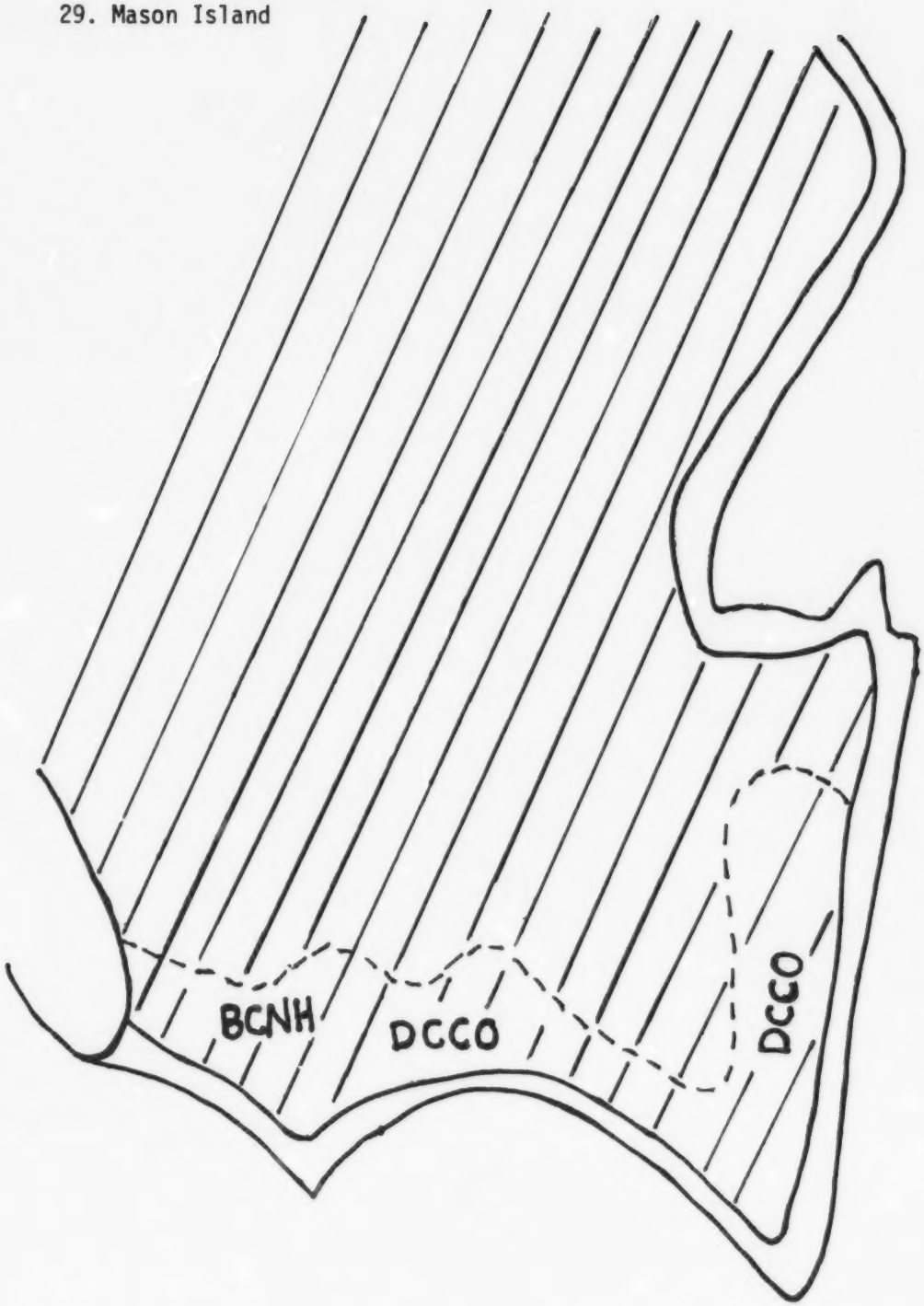


27. Vance's Reef

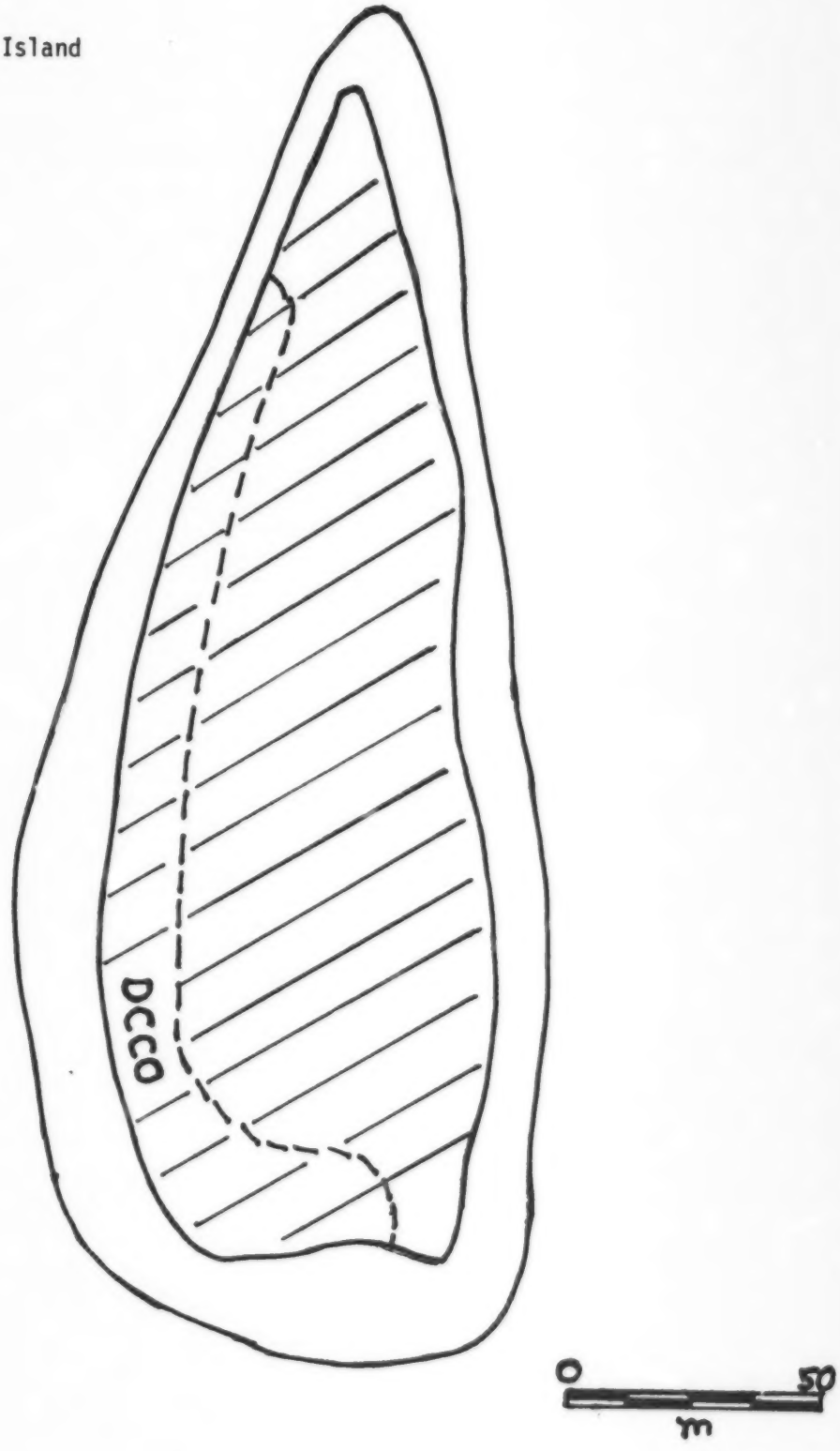
28. Mason Reef



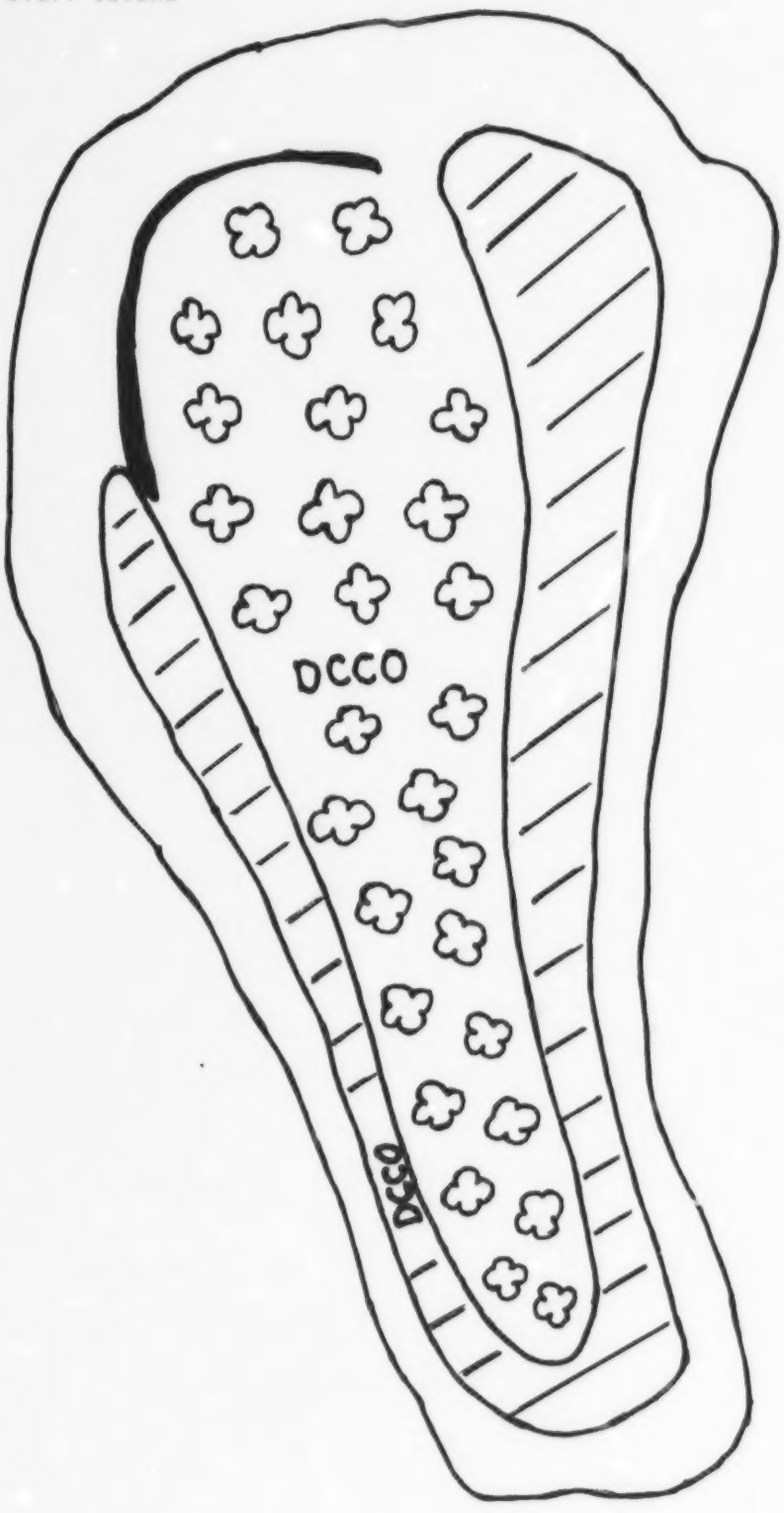
29. Mason Island



30. Balabas Island



31. Bluff Island



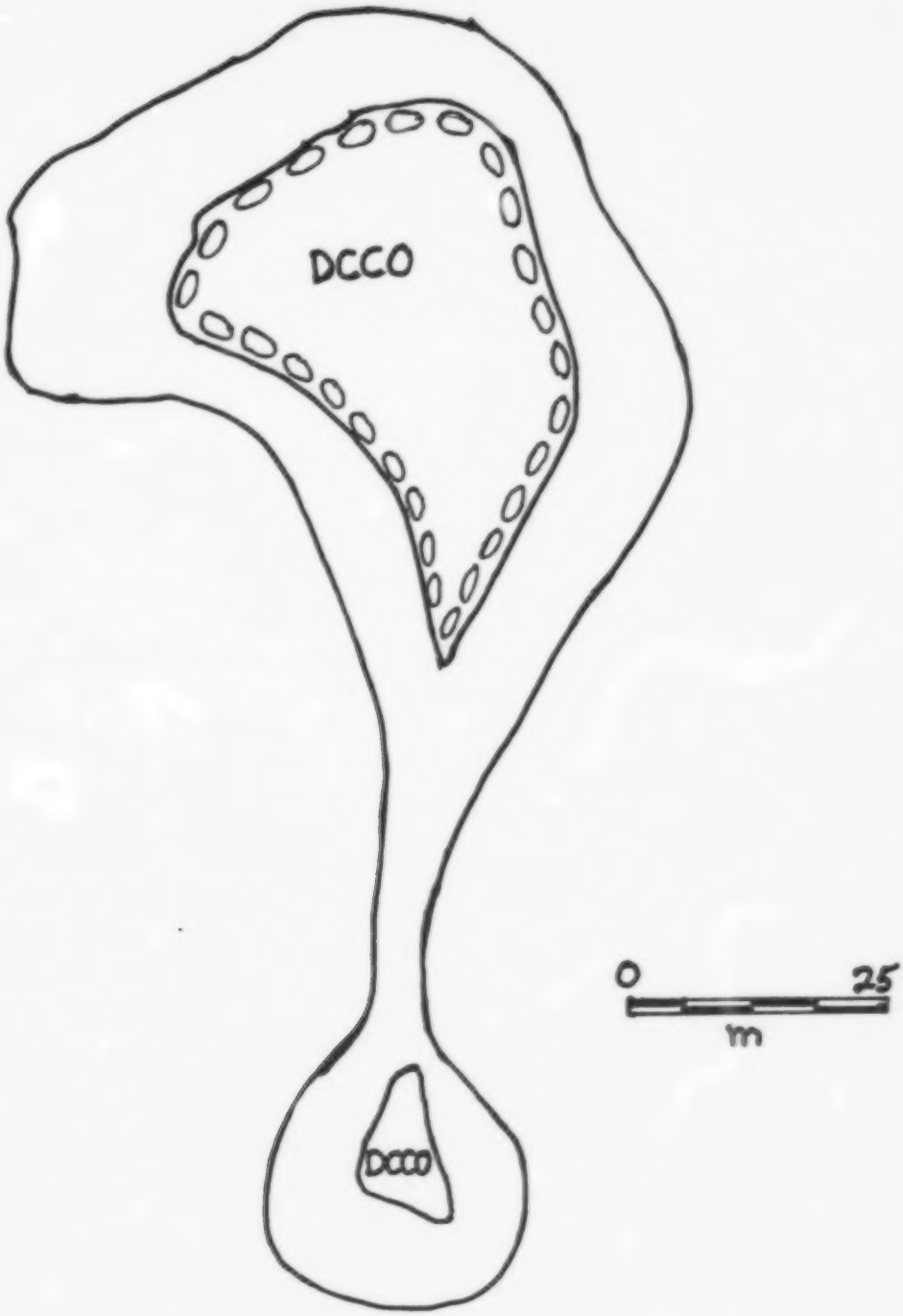
32. Angus Reef

33. Archie's Island

34. The Gobbler

35. Rowan Island

36. Birch Point Reef



37. Whitefish Point Reef